

# **Assignment 3**

## Message Passing Interface

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# Contents

Introduction . . . . .	2
Demonstration of Setup . . . . .	3

# Introduction

MPI stands for Message Passing Interface. It is a specification for developers and users of message passing libraries. It is not a library, but a standard of which a library should be. MPI primarily addresses the message-passing parallel programming model. Message Passing Interface provides a widely used standard for writing message passing program. Features of MPI:

- Practicality
- Portability
- High Efficiency
- Flexibility

MPI Supports the following hardware platforms:

- Distributed Memory
- Shared Memory
- Hybrid

## Reasons for using MPI

- **Standardization** - It is supported on all HPC platforms. It has replaced all previous message passing libraries.
- **Portability** - There is little or no need to modify your source code when you port your application to a different platform that supports (and is compliant with) the MPI standard.
- **Performance Opportunities** - Vendor implementations should be able to exploit native hardware features to optimize performance. Any implementation is free to develop optimized algorithms.
- **Functionality** - There are 430 routines defined in MPI-3.

# Demonstration of Setup

## Server Setup

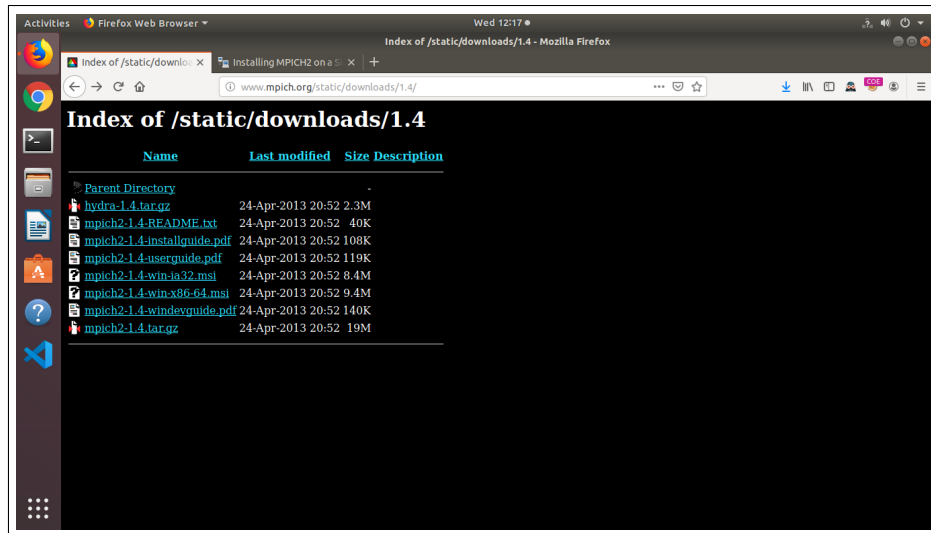


Figure 1: Downloading the MPICH2 version 1.4

```
coep@coep-HP-Compaq-6200-Pro-SFF-PC: ~/Downloads/mpich2-1.4
File Edit View Search Terminal Help
coep@coep-HP-Compaq-6200-Pro-SFF-PC:~/Downloads/mpich2-1.4$ ls
CHANGES      examples      mpich2.sln    README.winbin.rtf
confdb        maint         mpich2s.vcproj RELEASE_NOTES
configure     Makefile.in   mpich2.vcproj src
configure.in  Makefile.sm   mpi.def       test
contrib       makewindist.bat mpi.vcproj    winconfigure.wsf
COPYRIGHT     man           mpl.vcproj    www
COPYRIGHT.rtf mpich2.def    README
doc           mpich2-doxxygen.in README.envvar
coep@coep-HP-Compaq-6200-Pro-SFF-PC:~/Downloads/mpich2-1.4$
```

Figure 2: Contents of the extracted file mpich2-1-4.tar.gz

```
coep@coep-HP-Compaq-6200-Pro-SFF-PC: ~/Downloads/mpich2-1.4
File Edit View Search Terminal Help
config.status: creating errors/spawn/Makefile
config.status: creating errors/topo/Makefile
config.status: creating errors/io/Makefile
config.status: creating errors/cxx/Makefile
config.status: creating errors/cxx/errhan/Makefile
config.status: creating errors/cxx/io/Makefile
config.status: creating errors/f77/Makefile
config.status: creating errors/f90/Makefile
config.status: creating manual/Makefile
config.status: creating manual/manyconnect
config.status: creating perf/Makefile
config.status: creating testlist
config.status: creating cxx/testlist
config.status: creating f77/testlist
config.status: creating f90/testlist
config.status: creating threads/testlist
config.status: creating errors/cxx/testlist
config.status: creating include/mpitestconf.h
config.status: executing default-1 commands
config.status: executing default-2 commands
config.status: executing default-3 commands
Configuration completed.
coep@coep-HP-Compaq-6200-Pro-SFF-PC:~/Downloads/mpich2-1.4$
```

Figure 3: ./configuration command executed successfully

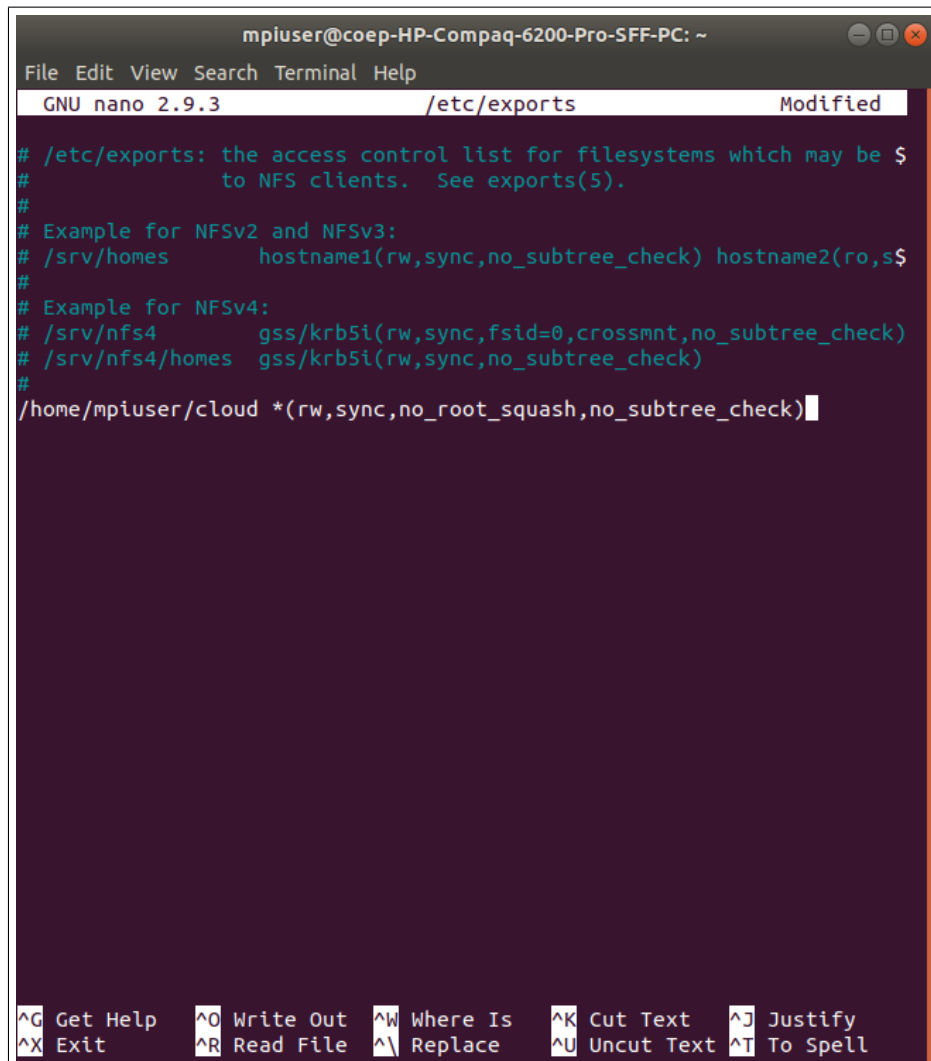


```
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC: ~  
File Edit View Search Terminal Help  
coep@coep-HP-Compaq-6200-Pro-SFF-PC:~/Downloads/mpich2-1.4$ su - mpiuser  
Password:  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~$  
  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~$
```

Figure 6: Login as mpiuser

```
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC: ~  
File Edit View Search Terminal Help  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~$ ssh-keygen -t dsa  
Generating public/private dsa key pair.  
Enter file in which to save the key (/home/mpiuser/.ssh/id_dsa):  
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_dsa.  
Your public key has been saved in /home/mpiuser/.ssh/id_dsa.pub.  
The key fingerprint is:  
SHA256:zRIzMOP7jqBd4Y0WjAY8Epm0p80ma16Jpw57zpGS8LM mpiuser@coep-HP-Compaq-6200-P  
ro-SFF-PC  
The key's randomart image is:  
+---[DSA 1024]---+  
|o+  +      |  
|oo. .  +   |  
|..+. .  +   |  
|..oo o . *   |  
|. = o = S o   |  
|+ooo. . * .   |  
| = . = + . = o |  
|. * = * + o   |  
|**E . . .   |  
+---[SHA256]---+  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~$
```

Figure 7: Generate SSH Key for secure Communication



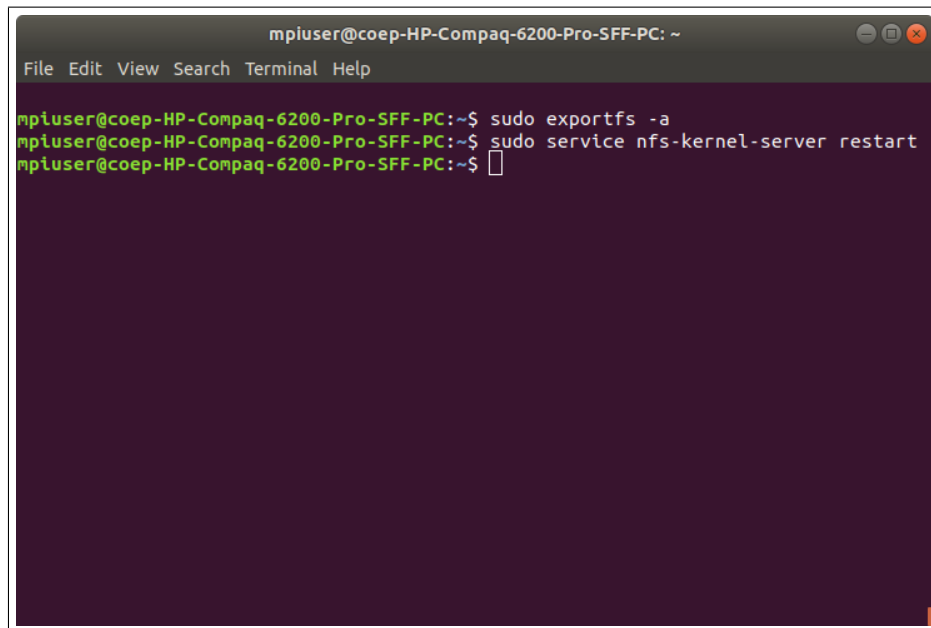
```
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC: ~
File Edit View Search Terminal Help
GNU nano 2.9.3 /etc/exports Modified

# /etc/exports: the access control list for filesystems which may be $
#               to NFS clients.  See exports(5).
#
# Example for NFSv2 and NFSv3:
# /srv/homes      hostname1(rw,sync,no_subtree_check) hostname2(ro,s$
#
# 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)
```

^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify  
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell

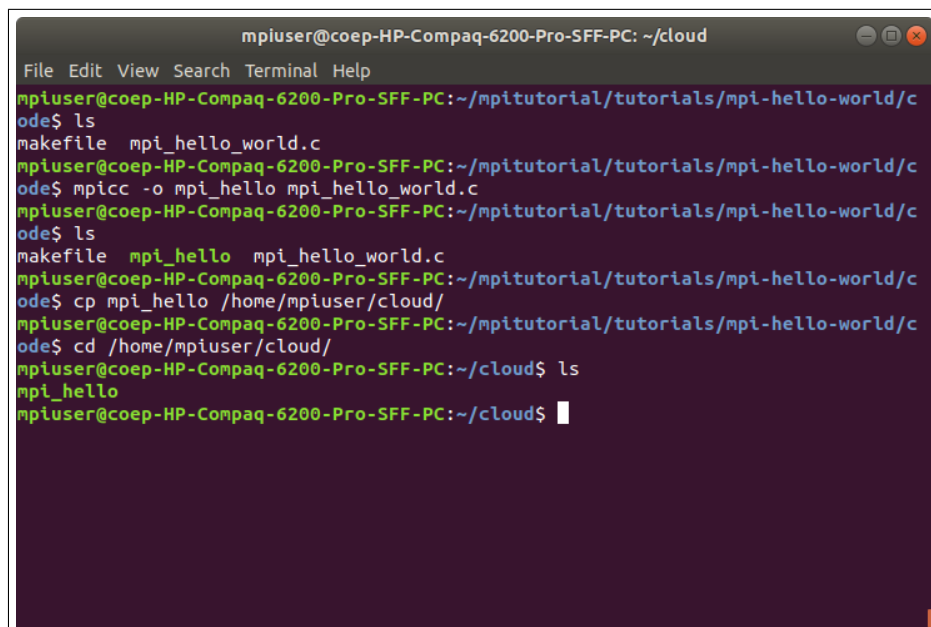
Figure 8: Editing the /etc/exports File



A terminal window titled 'mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC: ~' with a menu bar (File, Edit, View, Search, Terminal, Help). The terminal shows the user running two commands: 'sudo exportfs -a' and 'sudo service nfs-kernel-server restart'. The prompt returns to the user after each command.

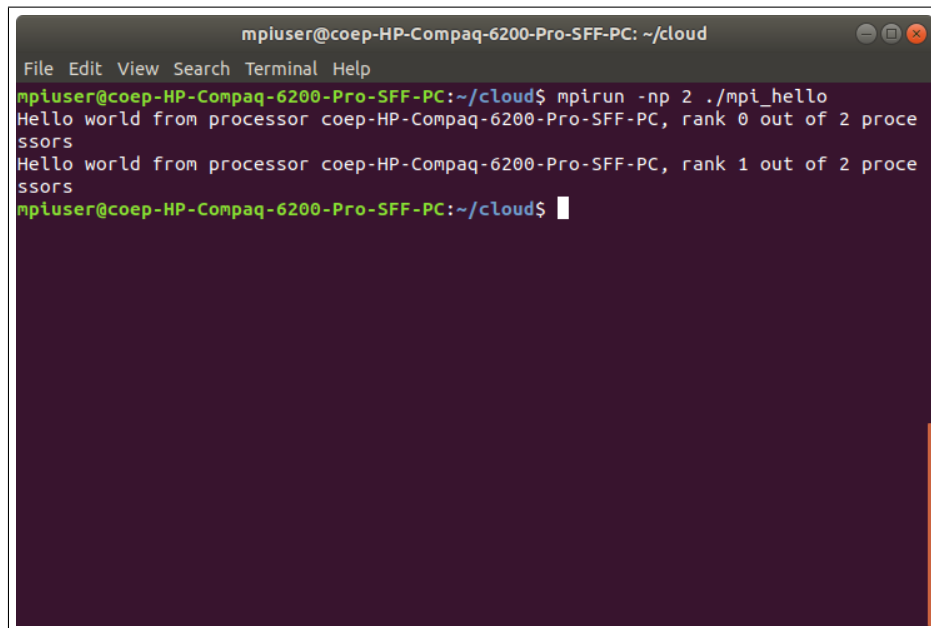
```
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC: ~  
File Edit View Search Terminal Help  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~$ sudo exportfs -a  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~$ sudo service nfs-kernel-server restart  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~$
```

Figure 9: Starting NFS Server

A terminal window titled 'mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC: ~/cloud' with a menu bar (File, Edit, View, Search, Terminal, Help). The user navigates to a directory, lists files, creates a Makefile, compiles a C program with 'mpicc', lists files again, copies the executable to the home directory, and then lists the contents of the home directory.

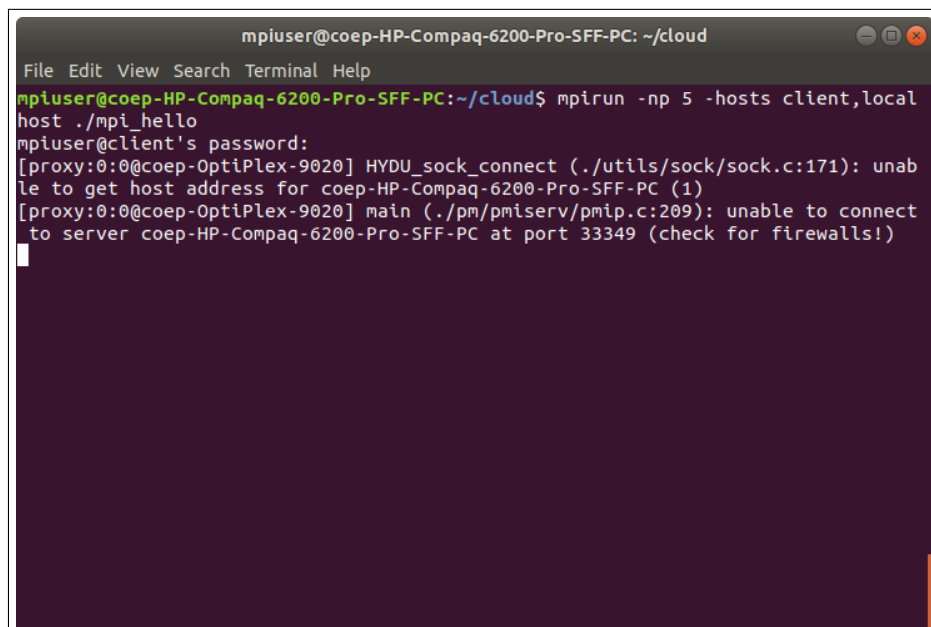
```
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC: ~/cloud  
File Edit View Search Terminal Help  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~/mpitutorial/tutorials/mpi-hello-world/c  
ode$ ls  
makefile  mpi_hello_world.c  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~/mpitutorial/tutorials/mpi-hello-world/c  
ode$ mpicc -o mpi_hello mpi_hello_world.c  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~/mpitutorial/tutorials/mpi-hello-world/c  
ode$ ls  
makefile  mpi_hello  mpi_hello_world.c  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~/mpitutorial/tutorials/mpi-hello-world/c  
ode$ cp mpi_hello /home/mpiuser/cloud/  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~/mpitutorial/tutorials/mpi-hello-world/c  
ode$ cd /home/mpiuser/cloud/  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~/cloud$ ls  
mpi_hello  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~/cloud$
```

Figure 10: Creating a shared Directory, compiling the Code and Transferring the executable to the shared folder

A terminal window titled 'mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC: ~/cloud'. The window contains the following text:

```
File Edit View Search Terminal Help
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~/cloud$ mpirun -np 2 ./mpi_hello
Hello world from processor coep-HP-Compaq-6200-Pro-SFF-PC, rank 0 out of 2 processors
Hello world from processor coep-HP-Compaq-6200-Pro-SFF-PC, rank 1 out of 2 processors
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~/cloud$
```

Figure 11: Running the mpi-hello-world.c program locally

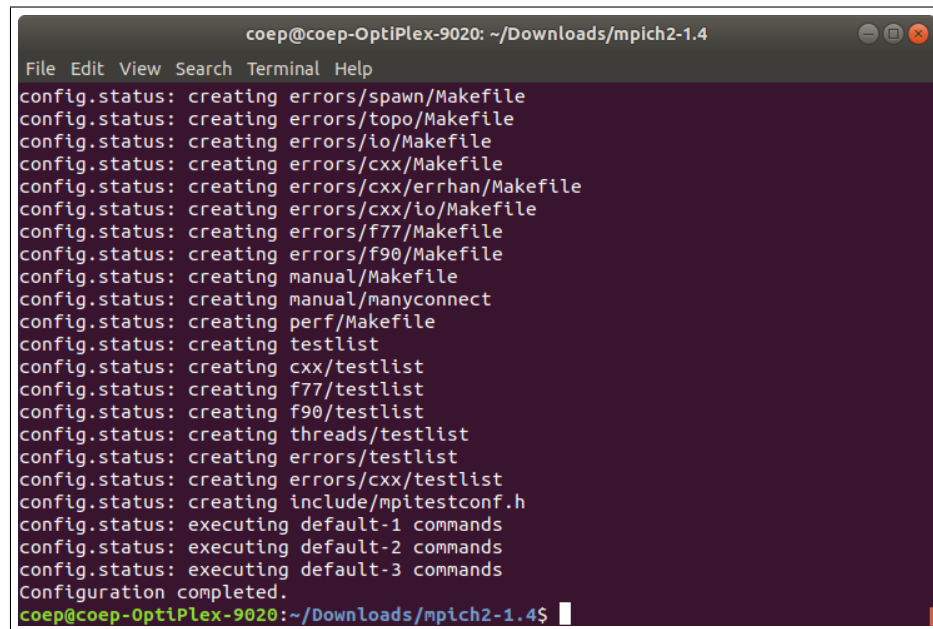
A terminal window titled 'mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC: ~/cloud'. The window contains the following text:

```
File Edit View Search Terminal Help
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~/cloud$ mpirun -np 5 -hosts client,local
host ./mpi_hello
mpiuser@client's password:
[proxy:0:0@coep-OptiPlex-9020] HYDU_sock_connect (./utils/sock/sock.c:171): unable
to get host address for coep-HP-Compaq-6200-Pro-SFF-PC (1)
[proxy:0:0@coep-OptiPlex-9020] main (./pm/pmiserv/pmip.c:209): unable to connect
to server coep-HP-Compaq-6200-Pro-SFF-PC at port 33349 (check for firewalls!)

```

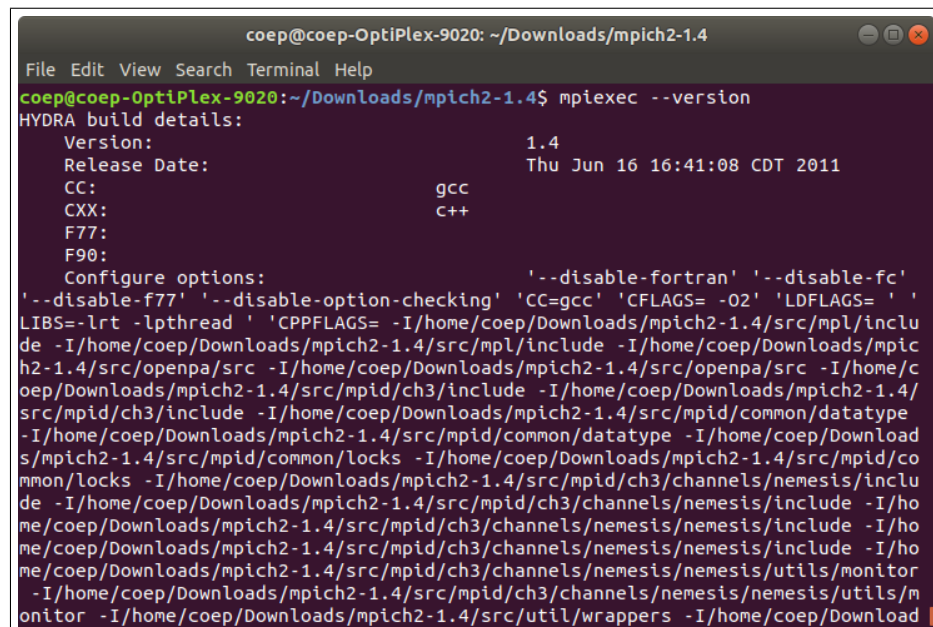
Figure 12: Running the mpi-hello-world.c program on a LAN

## Client Setup



```
coep@coep-OptiPlex-9020: ~/Downloads/mpich2-1.4
File Edit View Search Terminal Help
config.status: creating errors/spawn/Makefile
config.status: creating errors/topo/Makefile
config.status: creating errors/io/Makefile
config.status: creating errors/cxx/Makefile
config.status: creating errors/cxx/errhan/Makefile
config.status: creating errors/cxx/io/Makefile
config.status: creating errors/f77/Makefile
config.status: creating errors/f90/Makefile
config.status: creating manual/Makefile
config.status: creating manual/manyconnect
config.status: creating perf/Makefile
config.status: creating testlist
config.status: creating cxx/testlist
config.status: creating f77/testlist
config.status: creating f90/testlist
config.status: creating threads/testlist
config.status: creating errors/testlist
config.status: creating errors/cxx/testlist
config.status: creating include/mpitestconf.h
config.status: executing default-1 commands
config.status: executing default-2 commands
config.status: executing default-3 commands
Configuration completed.
coep@coep-OptiPlex-9020:~/Downloads/mpich2-1.4$
```

Figure 13: Configuration of MPICH2 completed Successfully



```
coep@coep-OptiPlex-9020: ~/Downloads/mpich2-1.4
File Edit View Search Terminal Help
coep@coep-OptiPlex-9020:~/Downloads/mpich2-1.4$ mpiexec --version
HYDRA build details:
Version: 1.4
Release Date: Thu Jun 16 16:41:08 CDT 2011
CC: gcc
CXX: c++
F77:
F90:
Configure options: '--disable-fortran' '--disable-fc'
'--disable-f77' '--disable-option-checking' 'CC=gcc' 'CFLAGS= -O2' 'LDFLAGS= '
LIBS=-lrt -lpthread 'CPPFLAGS= -I/home/coep/Downloads/mpich2-1.4/src/mpl/include -I/home/coep/Downloads/mpich2-1.4/src/openpa/src -I/home/coep/Downloads/mpich2-1.4/src/openpa/src -I/home/coep/Downloads/mpich2-1.4/src/mpid/ch3/include -I/home/coep/Downloads/mpich2-1.4/src/mpid/ch3/include -I/home/coep/Downloads/mpich2-1.4/src/mpid/common/datatype -I/home/coep/Downloads/mpich2-1.4/src/mpid/common/datatype -I/home/coep/Downloads/mpich2-1.4/src/mpid/common/locks -I/home/coep/Downloads/mpich2-1.4/src/mpid/common/locks -I/home/coep/Downloads/mpich2-1.4/src/mpid/ch3/channels/nemesis/include -I/home/coep/Downloads/mpich2-1.4/src/mpid/ch3/channels/nemesis/include -I/home/coep/Downloads/mpich2-1.4/src/mpid/ch3/channels/nemesis/nemesis/include -I/home/coep/Downloads/mpich2-1.4/src/mpid/ch3/channels/nemesis/nemesis/include -I/home/coep/Downloads/mpich2-1.4/src/mpid/ch3/channels/nemesis/nemesis/monitor -I/home/coep/Downloads/mpich2-1.4/src/mpid/ch3/channels/nemesis/nemesis/monitor -I/home/coep/Downloads/mpich2-1.4/src/util/wrappers -I/home/coep/Download
```

Figure 14: MPICH2-1.4 version details

```
coep@coep-OptiPlex-9020: ~/Downloads/mpich2-1.4
File Edit View Search Terminal Help
coep@coep-OptiPlex-9020:~/Downloads/mpich2-1.4$ cat /etc/hosts
127.0.0.1    localhost
127.0.1.1    coep-OptiPlex-9020
10.1.26.111  master

# 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
coep@coep-OptiPlex-9020:~/Downloads/mpich2-1.4$
```

Figure 15: Contents of hosts file

```
coep@coep-OptiPlex-9020: ~/Downloads/mpich2-1.4
File Edit View Search Terminal Help
coep@coep-OptiPlex-9020:~/Downloads/mpich2-1.4$ sudo adduser mpiuser
Adding user 'mpiuser' ...
Adding new group 'mpiuser' (1002) ...
Adding new user 'mpiuser' (1002) with group 'mpiuser' ...
Creating home directory '/home/mpiuser' ...
Copying files from '/etc/skel' ...
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
Changing the user information for mpiuser
Enter the new value, or press ENTER for the default
    Full Name []: Atharva
    Room Number []: 1
    Work Phone []:
    Home Phone []:
    Other []:
Is the information correct? [Y/n] Y
coep@coep-OptiPlex-9020:~/Downloads/mpich2-1.4$
```

Figure 16: Adding a new user

```
mpiuser@coep-OptiPlex-9020: ~  
File Edit View Search Terminal Help  
coep@coep-OptiPlex-9020:~/Downloads/mpich2-1.4$ su - mpiuser  
Password:  
mpiuser@coep-OptiPlex-9020:~$
```

Figure 17: Switching to mpiuser

```
mpiuser@coep-OptiPlex-9020: ~  
File Edit View Search Terminal Help  
mpiuser@coep-OptiPlex-9020:~$ ssh-keygen -t dsa  
Generating public/private dsa key pair.  
Enter file in which to save the key (/home/mpiuser/.ssh/id_dsa):  
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_dsa.  
Your public key has been saved in /home/mpiuser/.ssh/id_dsa.pub.  
The key fingerprint is:  
SHA256:BgKiXUw7I/him6XQczYo08tYmqiFQWgmvtJdwinIvRI mpiuser@coep-OptiPlex-9020  
The key's randomart image is:  
+----[DSA 1024]-----+  
|  
|.   
|o+ .   
|Bo.+ o   
|+E+.@ . S   
| XoB.* .   
|O+@o= . o   
|=@*= . o   
|B+o   
+----[SHA256]-----+  
mpiuser@coep-OptiPlex-9020:~$
```

Figure 18: Generating Key for Secure Communication

```
mpiuser@coep-OptiPlex-9020: ~  
File Edit View Search Terminal Help  
mpiuser@coep-OptiPlex-9020:~$ ssh-copy-id master  
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/home/mpiuser/.ssh/id_dsa.pub"  
The authenticity of host 'master (10.1.26.111)' can't be established.  
ECDSA key fingerprint is SHA256:0IqxuRPRGHwVCZyUMiXmVR35pRGFDuXbboAYODH9rm8.  
Are you sure you want to continue connecting (yes/no)? yes  
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed  
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys  
mpiuser@master's password:  
  
Number of key(s) added: 1  
  
Now try logging into the machine, with: "ssh 'master'"  
and check to make sure that only the key(s) you wanted were added.  
mpiuser@coep-OptiPlex-9020:~$
```

Figure 19: Registering the Master

```
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC: ~  
File Edit View Search Terminal Help  
mpiuser@coep-OptiPlex-9020:~$ ssh master  
mpiuser@master's password:  
Welcome to Ubuntu 18.04.3 LTS (GNU/Linux 4.15.0-65-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  
  
0 packages can be updated.  
0 updates are security updates.  
  
Last login: Wed Nov  6 12:47:28 2019 from 10.1.26.183  
mpiuser@coep-HP-Compaq-6200-Pro-SFF-PC:~$
```

Figure 20: Trying to SSH to master. Successful Attempt.

```

mpiuser@coep-OptiPlex-9020: ~
File Edit View Search Terminal Help

mpiuser@coep-OptiPlex-9020:~$ mkdir cloud
mpiuser@coep-OptiPlex-9020:~$ sudo mount -t nfs master:/home/mpiuser/c
cloud/ ~/cloud/
[sudo] password for mpiuser:
mpiuser@coep-OptiPlex-9020:~$ df -h

```

Filesystem	Size	Used	Avail	Use%	Mounted on
udev	3.9G	0	3.9G	0%	/dev
tmpfs	789M	2.2M	787M	1%	/run
/dev/sda7	19G	6.2G	12G	35%	/
tmpfs	3.9G	94M	3.8G	3%	/dev/shm
tmpfs	5.0M	4.0K	5.0M	1%	/run/lock
tmpfs	3.9G	0	3.9G	0%	/sys/fs/cgroup
/dev/loop3	3.8M	3.8M	0	100%	/snap/gnome-system-m
onitor/100					
/dev/loop0	4.3M	4.3M	0	100%	/snap/gnome-calculat
or/544					
/dev/loop2	3.8M	3.8M	0	100%	/snap/gnome-system-m
onitor/107					
/dev/loop1	89M	89M	0	100%	/snap/core/7270
/dev/loop5	157M	157M	0	100%	/snap/gnome-3-28-180
4/91					
/dev/loop6	150M	150M	0	100%	/snap/gnome-3-28-180
4/71					
/dev/loop4	4.3M	4.3M	0	100%	/snap/gnome-calculat
or/536					
/dev/loop8	1.0M	1.0M	0	100%	/snap/gnome-logs/61
/dev/loop9	1.0M	1.0M	0	100%	/snap/gnome-logs/81
/dev/loop10	43M	43M	0	100%	/snap/gtk-common-the
mes/1313					
/dev/loop7	90M	90M	0	100%	/snap/core/7917
/dev/loop11	55M	55M	0	100%	/snap/core18/1265
/dev/loop15	133M	133M	0	100%	/snap/code/17
/dev/loop14	15M	15M	0	100%	/snap/gnome-characte
rs/359					
/dev/loop16	203M	203M	0	100%	/snap/vlc/1049
/dev/loop12	45M	45M	0	100%	/snap/gtk-common-the
mes/1353					

Figure 21: Mounting the Shared Folder in NFS - Part 1

```

mpiususer@coep-OptiPlex-9020: ~
File Edit View Search Terminal Help
/dev/loop1      89M   89M   0 100% /snap/core/7270
/dev/loop5     157M  157M   0 100% /snap/gnome-3-28-1804/91
/dev/loop6     150M  150M   0 100% /snap/gnome-3-28-1804/71
/dev/loop4      4.3M   4.3M   0 100% /snap/gnome-calculator/536
/dev/loop8      1.0M   1.0M   0 100% /snap/gnome-logs/61
/dev/loop9      1.0M   1.0M   0 100% /snap/gnome-logs/81
/dev/loop10     43M   43M   0 100% /snap/gtk-common-themes/1313
/dev/loop7      90M   90M   0 100% /snap/core/7917
/dev/loop11     55M   55M   0 100% /snap/core18/1265
/dev/loop15    133M  133M   0 100% /snap/code/17
/dev/loop14     15M   15M   0 100% /snap/gnome-characters/359
/dev/loop16    203M  203M   0 100% /snap/vlc/1049
/dev/loop12     45M   45M   0 100% /snap/gtk-common-themes/1353
/dev/loop13     15M   15M   0 100% /snap/gnome-characters/317
/dev/loop17    137M  137M   0 100% /snap/code/18
/dev/loop18     55M   55M   0 100% /snap/core18/1223
/dev/sda2       96M   32M   65M  33% /boot/efi
/dev/sda8       76G   33G   40G  46% /home
tmpfs           789M   16K   789M   1% /run/user/121
tmpfs           789M   28K   789M   1% /run/user/1000
tmpfs           789M   36K   789M   1% /run/user/1001
tmpfs           789M    0   789M   0% /run/user/1002
master:/home/mpiususer/cloud 458G   60G  376G  14% /home/mpiususer/cloud
mpiususer@coep-OptiPlex-9020:~$

```

Figure 22: Mounting the Shared Folder in NFS - Part 2

```

mpiususer@coep-OptiPlex-9020: ~
File Edit View Search Terminal Help
/dev/loop1      89M   89M   0 100% /snap/core/7270
/dev/loop5     157M  157M   0 100% /snap/gnome-3-28-1804/91
/dev/loop6     150M  150M   0 100% /snap/gnome-3-28-1804/71
/dev/loop4      4.3M   4.3M   0 100% /snap/gnome-calculator/536
/dev/loop8      1.0M   1.0M   0 100% /snap/gnome-logs/61
/dev/loop9      1.0M   1.0M   0 100% /snap/gnome-logs/81
/dev/loop10     43M   43M   0 100% /snap/gtk-common-themes/1313
/dev/loop7      90M   90M   0 100% /snap/core/7917
/dev/loop11     55M   55M   0 100% /snap/core18/1265
/dev/loop15    133M  133M   0 100% /snap/code/17
/dev/loop14     15M   15M   0 100% /snap/gnome-characters/359
/dev/loop16    203M  203M   0 100% /snap/vlc/1049
/dev/loop12     45M   45M   0 100% /snap/gtk-common-themes/1353
/dev/loop13     15M   15M   0 100% /snap/gnome-characters/317
/dev/loop17    137M  137M   0 100% /snap/code/18
/dev/loop18     55M   55M   0 100% /snap/core18/1223
/dev/sda2       96M   32M   65M  33% /boot/efi
/dev/sda8       76G   33G   40G  46% /home
tmpfs           789M   16K   789M   1% /run/user/121
tmpfs           789M   28K   789M   1% /run/user/1000
tmpfs           789M   36K   789M   1% /run/user/1001
tmpfs           789M    0   789M   0% /run/user/1002
master:/home/mpiususer/cloud 458G   60G  376G  14% /home/mpiususer/cloud
mpiususer@coep-OptiPlex-9020:~$

```

Figure 23: Highlighting the Shared Directory



```
mpiususer@coep-OptiPlex-9020: ~  
File Edit View Search Terminal Help  
GNU nano 2.9.3 /etc/fstab Modified  
  
# /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/sda7 during installation  
UUID=f5c80603-0d3a-49a6-8c40-4588d9dbb0b5 / ext4 errors=remoun$  
# /boot/efi was on /dev/sda2 during installation  
UUID=D2DF-7DAF /boot/efi vfat umask=0077 0 1  
# /home was on /dev/sda8 during installation  
UUID=00f5ba22-7dd8-4f30-bcb2-f77a211c0dae /home ext4 defaults $  
# swap was on /dev/sda6 during installation  
UUID=7d252bd1-da51-453e-b80e-fa0f8f4238ad none swap sw $  
# MPI Cluster Setup  
master:/home/mpiususer/cloud /home/mpiususer/cloud nfs
```

^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

Figure 24: Contents of fstab file to permanently mount the shared folder.