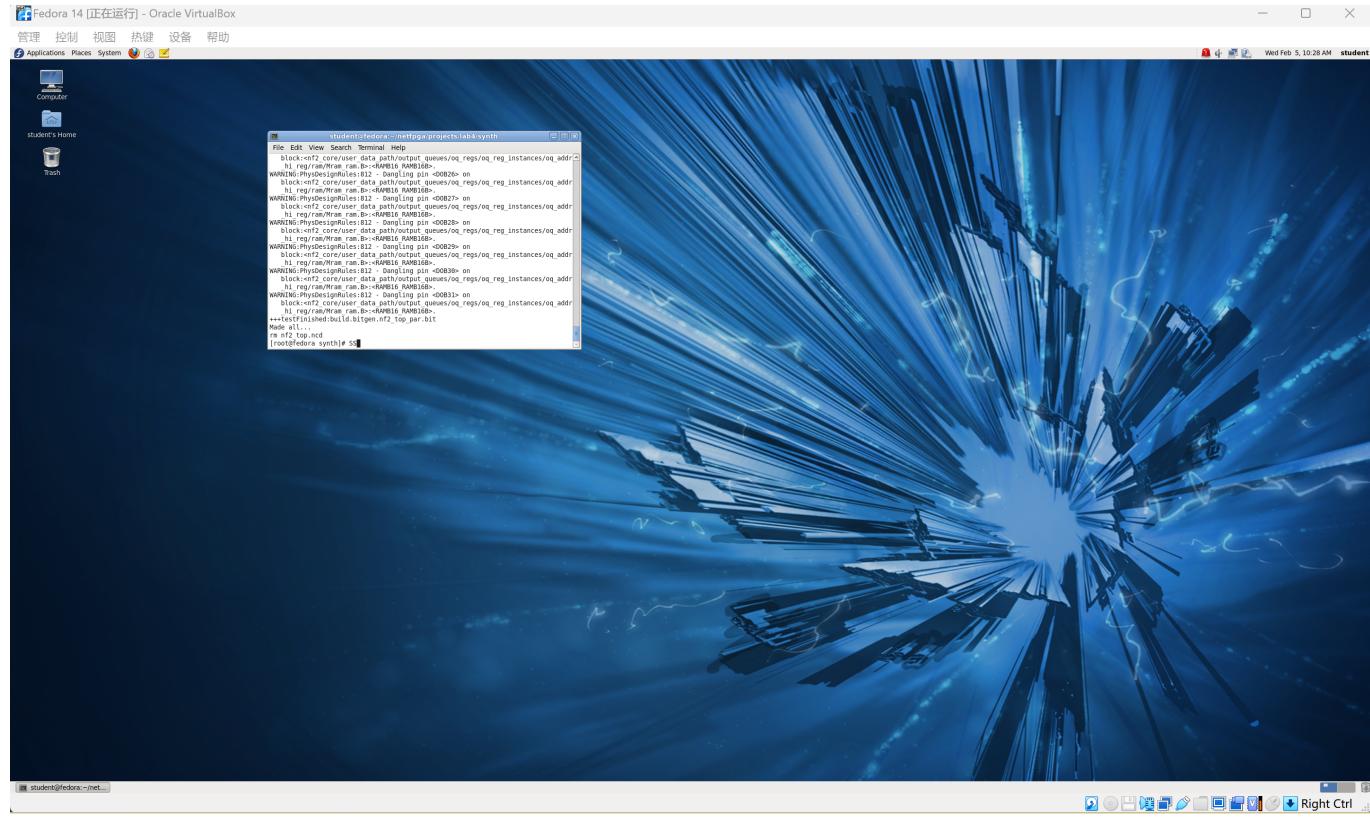


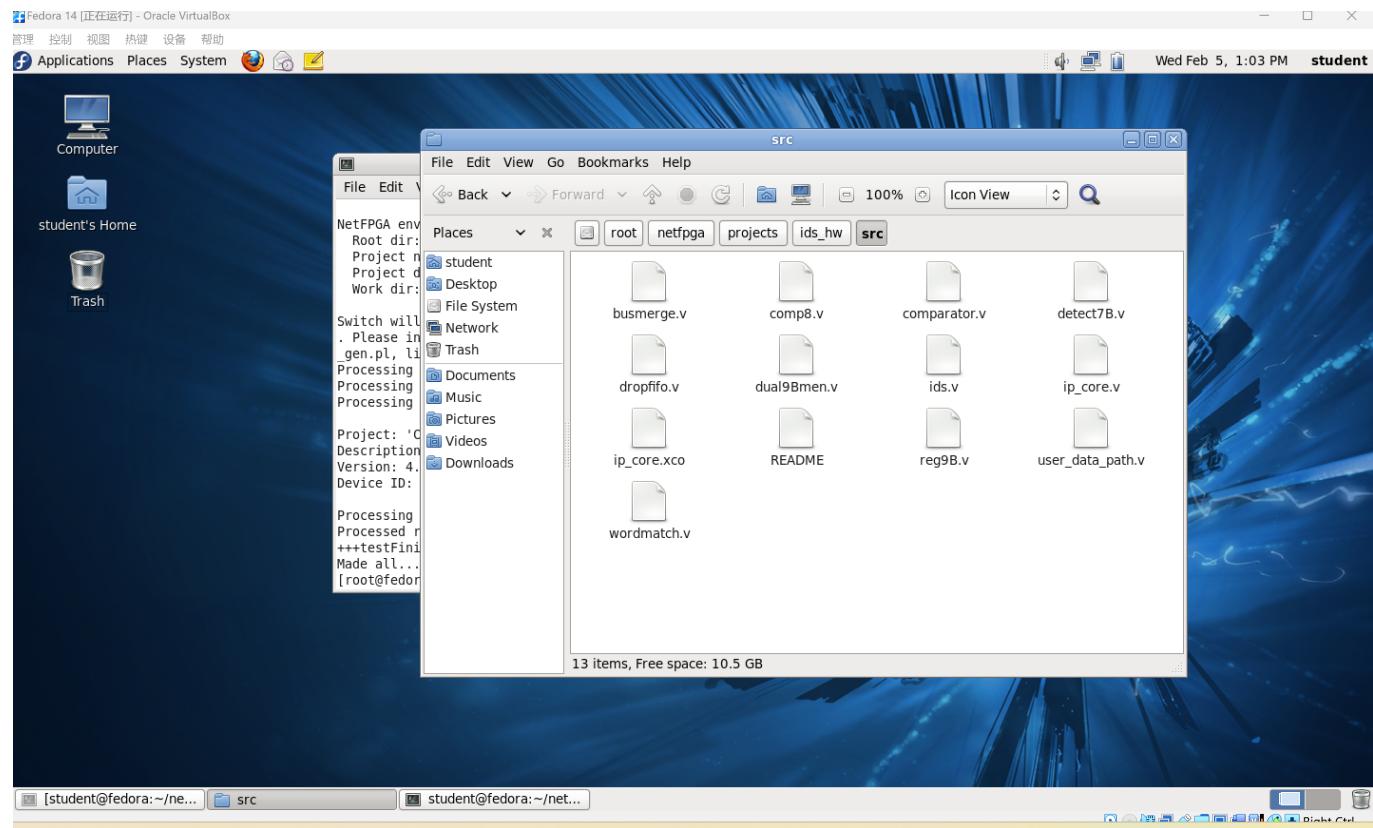
# EE533\_Lab4\_Report

## 1. Download and Setup Fedora VM

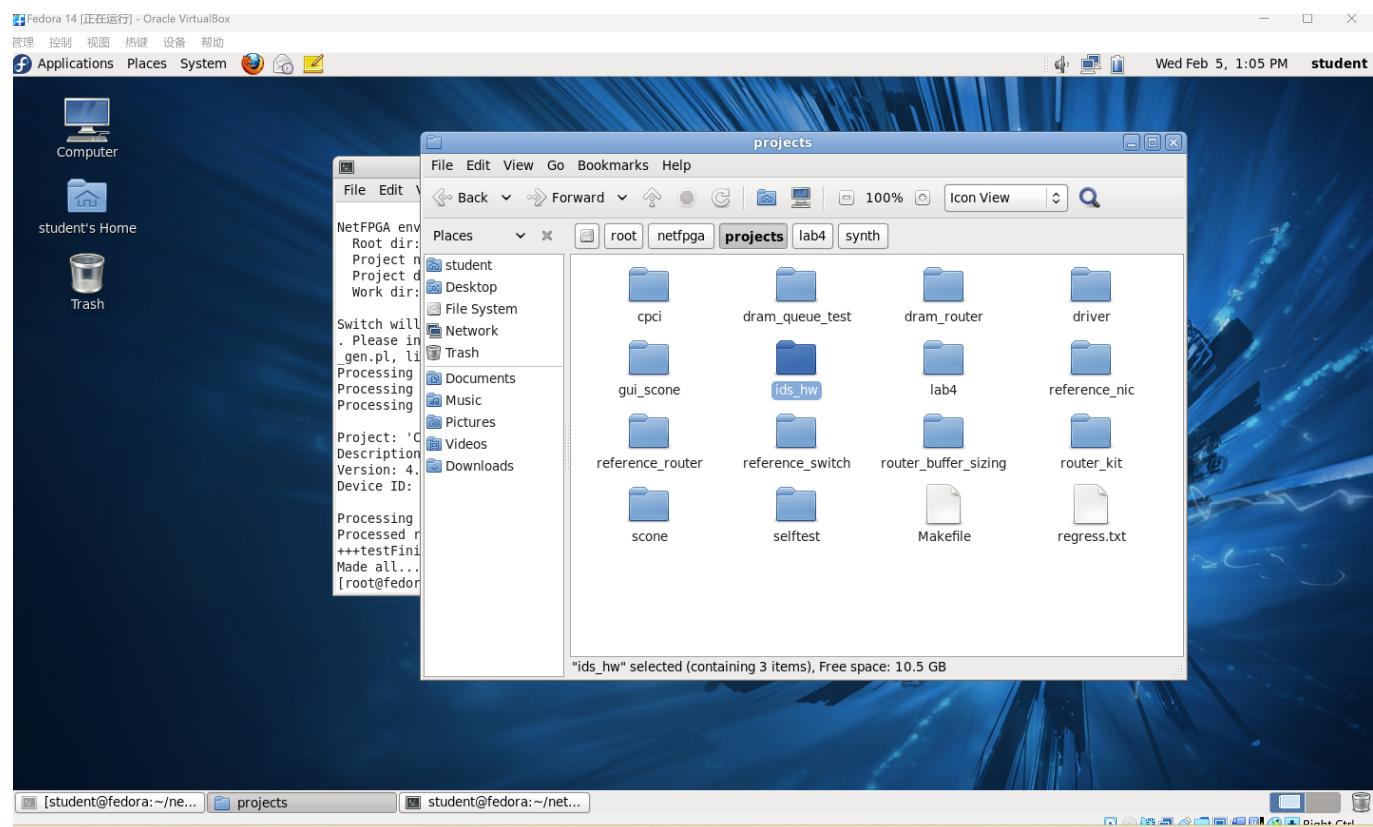


## 2. Compile and generate a design bitfile for NetFPGA

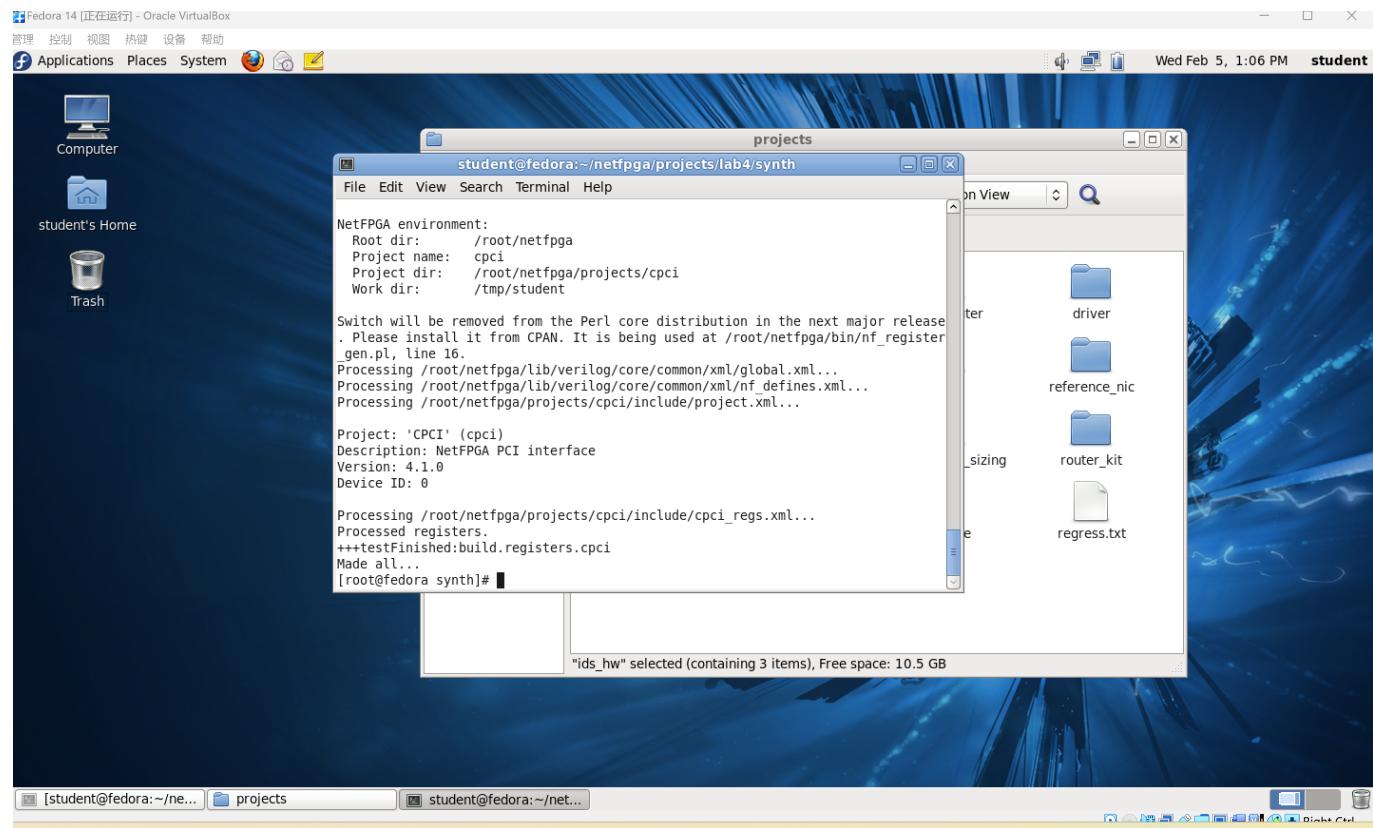
### 2.1 Extract ids\_hw and copy all Verilog and ip core files into ids\_hw/src



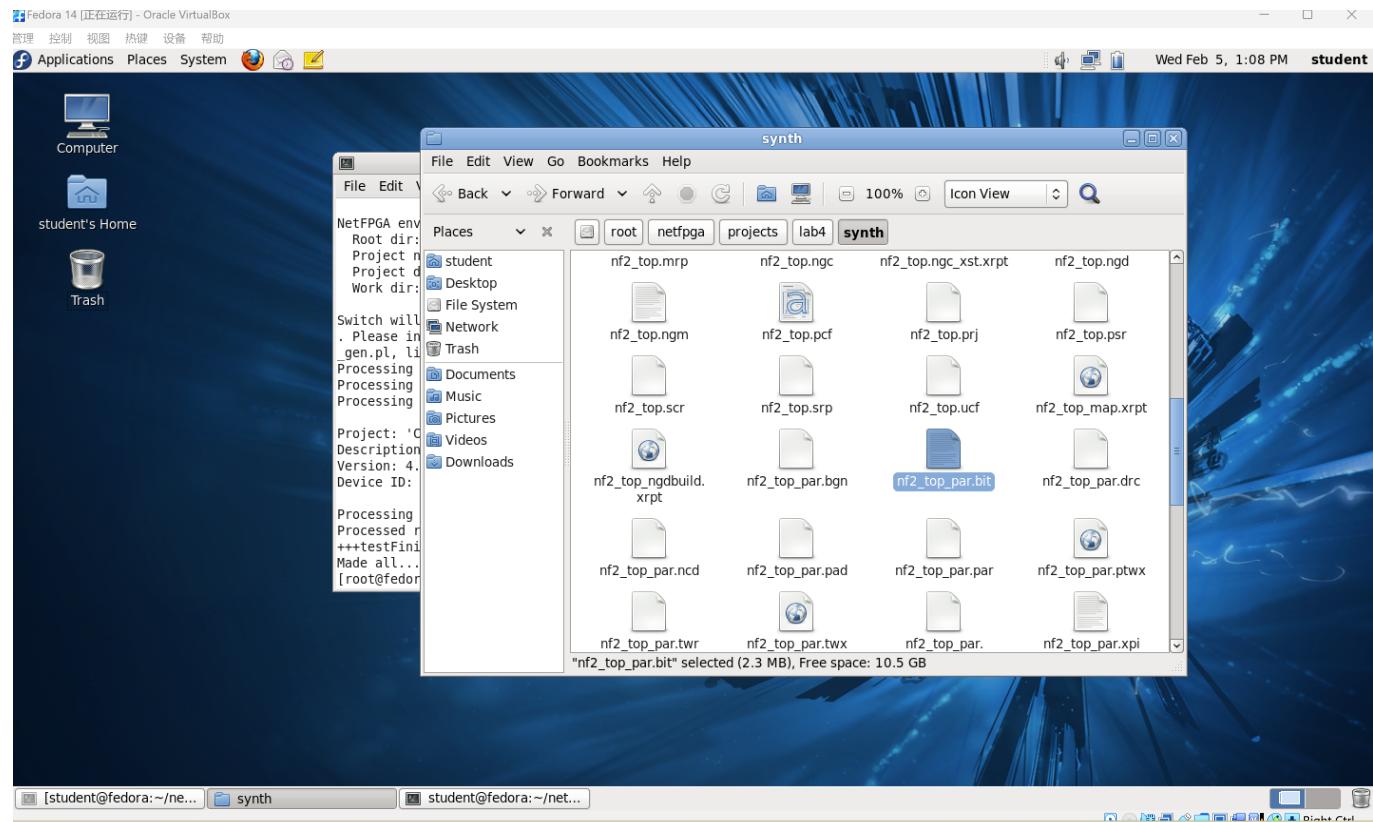
## 2.2 Copy all of source files within ids\_hw into corresponding folders into NetFPGA project folder



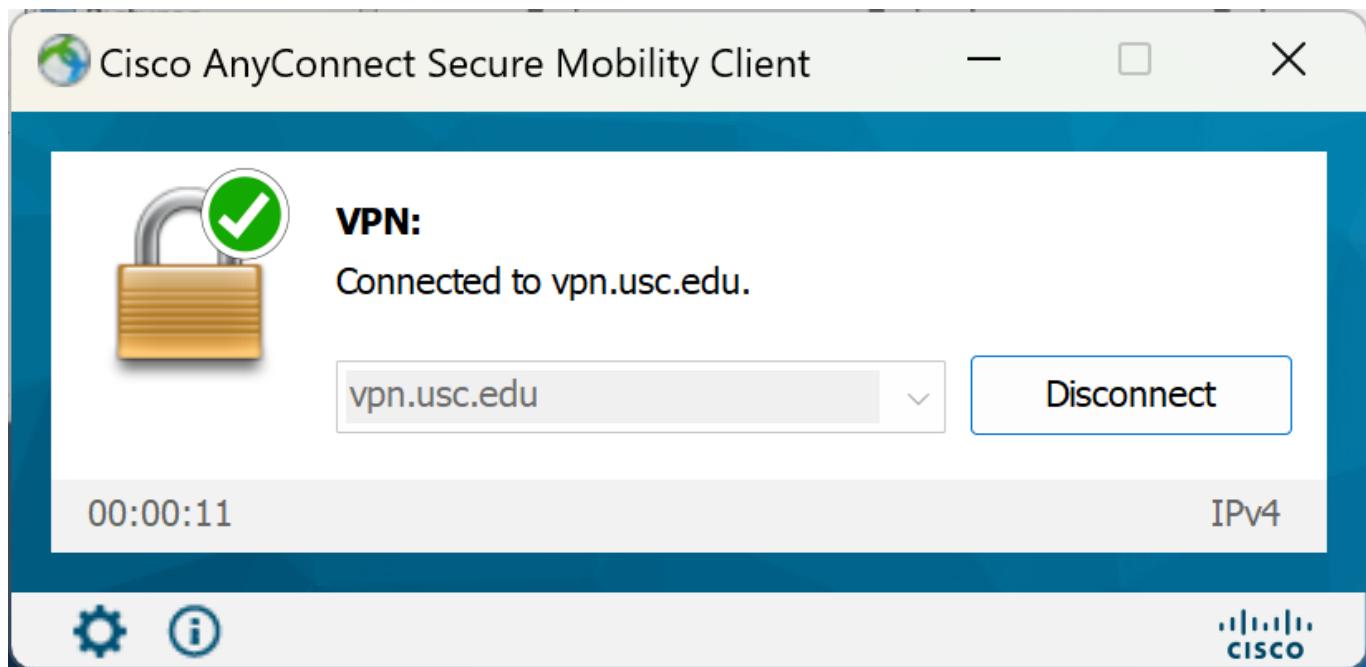
## 2.3 Compile the design by 'cd' into the synth folder type 'make'



## 2.4 '\*.bit' file generated



## 3. Set Up VPN to USC



## 4. NetFPGA Environment

echo test results

```
netfpga@nf8:~
```

```
last login: Fri Feb  7 02:05:23 2025 from 10.21.32.158
[team-8:fpga ~] echo $n0
0.0.12.3
[team-8:fpga ~] echo $n1
0.0.13.3
[team-8:fpga ~] echo $n2
0.0.14.3
[team-8:fpga ~] echo $n3
0.0.15.3
[team-8:fpga ~]
```

## 5. NetFPGA-based Linux Kernel IP Router

### 5.1 Test NetFPGA as network interface card

```

Last login: Fri Feb  7 02:07:01 2025 from 10.48.160.142
[team-8:fpga ~] nf_download /home/netfpga/bitfiles/reference_nic.bit
Found net device: nf2c0
Bit file built from: nf2_top_par.ncd;HW_TIMEOUT=FALSE
Part: 2vp50ff1152
Date: 2011/11/17
Time: 16:21:17
Error Registers: 0
Good, after resetting programming interface the FIFO is empty
Download completed - 2377668 bytes. (expected 2377668).
DONE went high - chip has been successfully programmed.

CPCI Information
-----
Version: 4 (rev 1)

Device (Virtex) Information
-----
Project directory: reference_nic
Project name: Reference NIC
Project description: Reference NIC

Device ID: 1
Version: 1.1.0
Built against CPCI version: 4 (rev 1)

Virtex design compiled against active CPCI version
[team-8:fpga ~]

```

## 5.2 Test ping from n0 to n3

```

Last login: Fri Feb  7 01:55:11 2025 from 10.48.160.142
[team-8:n0 ~] ping $n3
PING 10.0.15.3 (10.0.15.3) 56(84) bytes of data.
64 bytes from 10.0.15.3: icmp_seq=1 ttl=63 time=2.36 ms
64 bytes from 10.0.15.3: icmp_seq=2 ttl=63 time=0.708 ms
64 bytes from 10.0.15.3: icmp_seq=3 ttl=63 time=0.985 ms
64 bytes from 10.0.15.3: icmp_seq=4 ttl=63 time=0.901 ms
64 bytes from 10.0.15.3: icmp_seq=5 ttl=63 time=0.944 ms
64 bytes from 10.0.15.3: icmp_seq=6 ttl=63 time=0.965 ms
64 bytes from 10.0.15.3: icmp_seq=7 ttl=63 time=0.855 ms
64 bytes from 10.0.15.3: icmp_seq=8 ttl=63 time=0.903 ms
64 bytes from 10.0.15.3: icmp_seq=9 ttl=63 time=0.927 ms
64 bytes from 10.0.15.3: icmp_seq=10 ttl=63 time=0.985 ms
64 bytes from 10.0.15.3: icmp_seq=11 ttl=63 time=0.902 ms
64 bytes from 10.0.15.3: icmp_seq=12 ttl=63 time=1.06 ms
64 bytes from 10.0.15.3: icmp_seq=13 ttl=63 time=0.899 ms
64 bytes from 10.0.15.3: icmp_seq=14 ttl=63 time=0.907 ms
64 bytes from 10.0.15.3: icmp_seq=15 ttl=63 time=0.925 ms
64 bytes from 10.0.15.3: icmp_seq=16 ttl=63 time=0.967 ms
64 bytes from 10.0.15.3: icmp_seq=17 ttl=63 time=1.08 ms
64 bytes from 10.0.15.3: icmp_seq=18 ttl=63 time=0.901 ms
64 bytes from 10.0.15.3: icmp_seq=19 ttl=63 time=1.09 ms
64 bytes from 10.0.15.3: icmp_seq=20 ttl=63 time=0.913 ms
64 bytes from 10.0.15.3: icmp_seq=21 ttl=63 time=0.902 ms
64 bytes from 10.0.15.3: icmp_seq=22 ttl=63 time=0.817 ms
64 bytes from 10.0.15.3: icmp_seq=23 ttl=63 time=0.882 ms
64 bytes from 10.0.15.3: icmp_seq=24 ttl=63 time=0.880 ms
64 bytes from 10.0.15.3: icmp_seq=25 ttl=63 time=0.984 ms
64 bytes from 10.0.15.3: icmp_seq=26 ttl=63 time=0.923 ms
64 bytes from 10.0.15.3: icmp_seq=27 ttl=63 time=0.845 ms
64 bytes from 10.0.15.3: icmp_seq=28 ttl=63 time=0.988 ms
64 bytes from 10.0.15.3: icmp_seq=29 ttl=63 time=0.949 ms
64 bytes from 10.0.15.3: icmp_seq=30 ttl=63 time=0.916 ms

```

## 5.3 Test ping from n0 to n3 by typing IP Address

- Checking n3 IP Address
  - 10.0.15.3

```

Last login: Fri Feb  7 02:07:01 2025 from 10.48.160.142
[team-8:fpga ~] nf_download /home/netfpga/bitfiles/reference_nic.bit
Found net device: nf2c0
Bit file built from: nf2_top_par.ncd;HW_TIMEOUT=FALSE
Part: 2vp50ff1152
Date: 2011/11/17
Time: 16:21:17
Error Registers: 0
Good, after resetting programming interface the FIFO is empty
Download completed - 2377668 bytes. (expected 2377668).
DONE went high - chip has been successfully programmed.
CPCI Information
-----
Version: 4 (rev 1)

Device (Virtex) Information
-----
Project directory: reference_nic
Project name: Reference NIC
Project description: Reference NIC

Device ID: 1
Version: 1.1.0
Built against CPCI version: 4 (rev 1)

Virtex design compiled against active CPCI version
[team-8:fpga ~] echo $n3
10.0.15.3
[team-8:fpga ~]

```

- Ping n3 by IP Address

```

64 bytes from 10.0.15.3: icmp_seq=27 ttl=63 time=0.845 ms
64 bytes from 10.0.15.3: icmp_seq=28 ttl=63 time=0.988 ms
64 bytes from 10.0.15.3: icmp_seq=29 ttl=63 time=0.949 ms
64 bytes from 10.0.15.3: icmp_seq=30 ttl=63 time=0.916 ms
64 bytes from 10.0.15.3: icmp_seq=31 ttl=63 time=0.928 ms
64 bytes from 10.0.15.3: icmp_seq=32 ttl=63 time=1.22 ms
64 bytes from 10.0.15.3: icmp_seq=33 ttl=63 time=1.43 ms
64 bytes from 10.0.15.3: icmp_seq=34 ttl=63 time=2.45 ms
^z64 bytes from 10.0.15.3: icmp_seq=35 ttl=63 time=4.57 ms
64 bytes from 10.0.15.3: icmp_seq=36 ttl=63 time=2.63 ms

[1]+ Stopped                  ping $n3
[team-8:n0 ~] ping 10.0.15.3
PING 10.0.15.3 (10.0.15.3) 56(84) bytes of data.
64 bytes from 10.0.15.3: icmp_seq=1 ttl=63 time=2.53 ms
64 bytes from 10.0.15.3: icmp_seq=2 ttl=63 time=1.00 ms
64 bytes from 10.0.15.3: icmp_seq=3 ttl=63 time=0.915 ms
64 bytes from 10.0.15.3: icmp_seq=4 ttl=63 time=0.903 ms
64 bytes from 10.0.15.3: icmp_seq=5 ttl=63 time=0.902 ms
64 bytes from 10.0.15.3: icmp_seq=6 ttl=63 time=0.868 ms
64 bytes from 10.0.15.3: icmp_seq=7 ttl=63 time=0.922 ms
64 bytes from 10.0.15.3: icmp_seq=8 ttl=63 time=0.896 ms
64 bytes from 10.0.15.3: icmp_seq=9 ttl=63 time=0.929 ms
64 bytes from 10.0.15.3: icmp_seq=10 ttl=63 time=0.883 ms
64 bytes from 10.0.15.3: icmp_seq=11 ttl=63 time=1.15 ms
64 bytes from 10.0.15.3: icmp_seq=12 ttl=63 time=1.02 ms
64 bytes from 10.0.15.3: icmp_seq=13 ttl=63 time=0.881 ms
64 bytes from 10.0.15.3: icmp_seq=14 ttl=63 time=0.902 ms
64 bytes from 10.0.15.3: icmp_seq=15 ttl=63 time=1.00 ms

[2]+ Stopped                  ping 10.0.15.3
[team-8:n0 ~]

```

## 5.4 Test Ping all other nodes from one to another

### 5.4.1 n0 -> n1, n2, n3

```

Feb 8 18:53
node3@nfs:~

64 bytes from 10.0.15.3: icmp_seq=8 ttl=63 time=0.896 ms
64 bytes from 10.0.15.3: icmp_seq=9 ttl=63 time=0.929 ms
64 bytes from 10.0.15.3: icmp_seq=10 ttl=63 time=0.883 ms
64 bytes from 10.0.15.3: icmp_seq=11 ttl=63 time=1.15 ms
64 bytes from 10.0.15.3: icmp_seq=12 ttl=63 time=1.02 ms
64 bytes from 10.0.15.3: icmp_seq=13 ttl=63 time=0.881 ms
64 bytes from 10.0.15.3: icmp_seq=14 ttl=63 time=0.902 ms
64 bytes from 10.0.15.3: icmp_seq=15 ttl=63 time=1.00 ms

[2]+ Stopped ping 10.0.15.3
[team-8:n0 ~] ping $n1
PING 10.0.13.3 (10.0.13.3) 56(84) bytes of data.
64 bytes from 10.0.13.3: icmp_seq=1 ttl=63 time=2.17 ms
64 bytes from 10.0.13.3: icmp_seq=2 ttl=63 time=0.999 ms
64 bytes from 10.0.13.3: icmp_seq=3 ttl=63 time=0.989 ms
64 bytes from 10.0.13.3: icmp_seq=4 ttl=63 time=0.866 ms

[3]+ Stopped ping $n1
[team-8:n0 ~] ping $n2
PING 10.0.14.3 (10.0.14.3) 56(84) bytes of data.
64 bytes from 10.0.14.3: icmp_seq=1 ttl=63 time=2.16 ms
64 bytes from 10.0.14.3: icmp_seq=2 ttl=63 time=1.07 ms

[4]+ Stopped ping $n2
[team-8:n0 ~] ping $n3
PING 10.0.15.3 (10.0.15.3) 56(84) bytes of data.
64 bytes from 10.0.15.3: icmp_seq=1 ttl=63 time=1.06 ms
64 bytes from 10.0.15.3: icmp_seq=2 ttl=63 time=0.973 ms
64 bytes from 10.0.15.3: icmp_seq=3 ttl=63 time=0.978 ms

[5]+ Stopped ping $n3
[team-8:n0 ~]

```

要将输入定向到该虚拟机，请将鼠标指针移入其中或按 Ctrl+G。

#### 5.4.2 n1 -> n0, n2, n3

```

Feb 8 18:54
node3@nfs:~

Last login: Fri Feb  7 01:59:01 2025 from 10.48.160.142
[team-8:n1 ~] ping $n0
PING 10.0.12.3 (10.0.12.3) 56(84) bytes of data.
64 bytes from 10.0.12.3: icmp_seq=1 ttl=63 time=1.19 ms
64 bytes from 10.0.12.3: icmp_seq=2 ttl=63 time=1.06 ms

[1]+ Stopped ping $n0
[team-8:n1 ~] ping $n1
PING 10.0.14.3 (10.0.14.3) 56(84) bytes of data.
64 bytes from 10.0.14.3: icmp_seq=1 ttl=63 time=1.38 ms
64 bytes from 10.0.14.3: icmp_seq=2 ttl=63 time=1.21 ms
64 bytes from 10.0.14.3: icmp_seq=3 ttl=63 time=0.976 ms

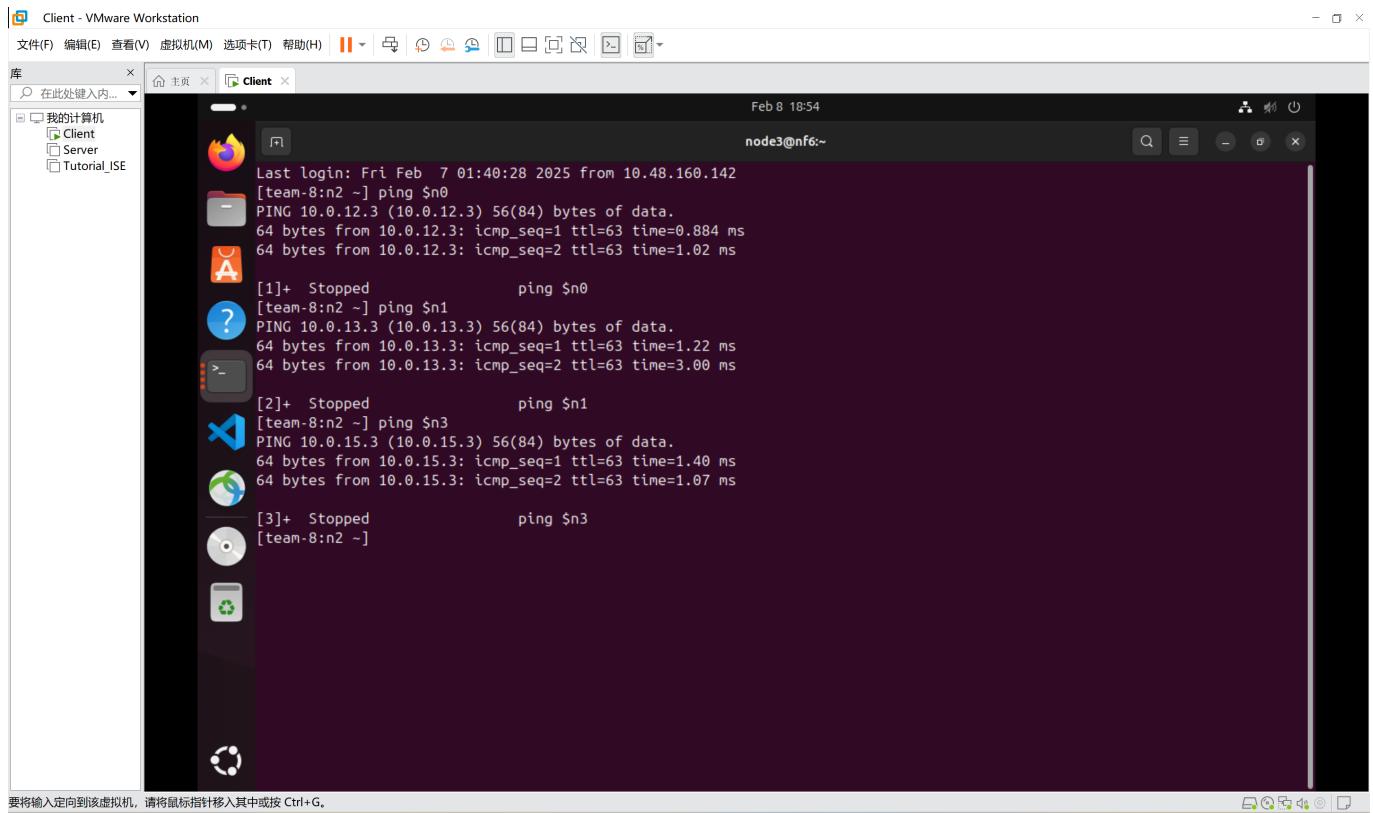
[2]+ Stopped ping $n1
[team-8:n1 ~] ping $n2
PING 10.0.15.3 (10.0.15.3) 56(84) bytes of data.
64 bytes from 10.0.15.3: icmp_seq=1 ttl=63 time=1.43 ms
64 bytes from 10.0.15.3: icmp_seq=2 ttl=63 time=1.02 ms
64 bytes from 10.0.15.3: icmp_seq=3 ttl=63 time=0.992 ms

[3]+ Stopped ping $n2
[team-8:n1 ~]

```

要将输入定向到该虚拟机，请将鼠标指针移入其中或按 Ctrl+G。

#### 5.4.3 n2 -> n0, n1, n3



```

Last login: Fri Feb  7 01:40:28 2025 from 10.48.160.142
[team-8:n2 ~] ping $n0
PING 10.0.12.3 (10.0.12.3) 56(84) bytes of data.
64 bytes from 10.0.12.3: icmp_seq=1 ttl=63 time=0.884 ms
64 bytes from 10.0.12.3: icmp_seq=2 ttl=63 time=1.02 ms

[1]+ Stopped ping $n0
[team-8:n2 ~] ping $n1
PING 10.0.13.3 (10.0.13.3) 56(84) bytes of data.
64 bytes from 10.0.13.3: icmp_seq=1 ttl=63 time=1.22 ms
64 bytes from 10.0.13.3: icmp_seq=2 ttl=63 time=3.00 ms

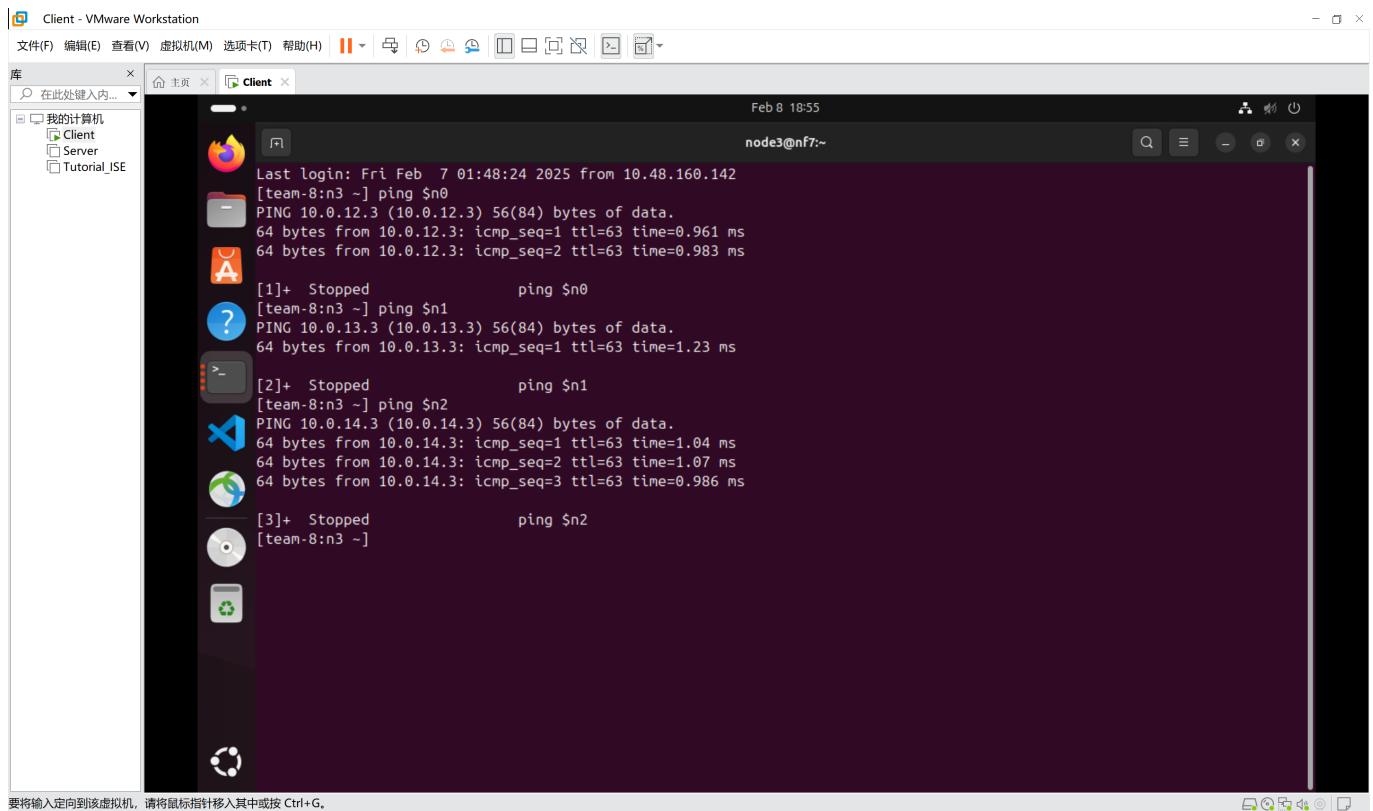
[2]+ Stopped ping $n1
[team-8:n2 ~] ping $n3
PING 10.0.15.3 (10.0.15.3) 56(84) bytes of data.
64 bytes from 10.0.15.3: icmp_seq=1 ttl=63 time=1.40 ms
64 bytes from 10.0.15.3: icmp_seq=2 ttl=63 time=1.07 ms

[3]+ Stopped ping $n3
[team-8:n2 ~]

```

要将输入定向到该虚拟机，请将鼠标指针移入其中或按 Ctrl+G。

#### 5.4.4 n3 -> n0, n1, n2



```

Last login: Fri Feb  7 01:48:24 2025 from 10.48.160.142
[team-8:n3 ~] ping $n0
PING 10.0.12.3 (10.0.12.3) 56(84) bytes of data.
64 bytes from 10.0.12.3: icmp_seq=1 ttl=63 time=0.961 ms
64 bytes from 10.0.12.3: icmp_seq=2 ttl=63 time=0.983 ms

[1]+ Stopped ping $n0
[team-8:n3 ~] ping $n1
PING 10.0.13.3 (10.0.13.3) 56(84) bytes of data.
64 bytes from 10.0.13.3: icmp_seq=1 ttl=63 time=1.23 ms

[2]+ Stopped ping $n1
[team-8:n3 ~] ping $n2
PING 10.0.14.3 (10.0.14.3) 56(84) bytes of data.
64 bytes from 10.0.14.3: icmp_seq=1 ttl=63 time=1.04 ms
64 bytes from 10.0.14.3: icmp_seq=2 ttl=63 time=1.07 ms
64 bytes from 10.0.14.3: icmp_seq=3 ttl=63 time=0.986 ms

[3]+ Stopped ping $n2
[team-8:n3 ~]

```

要将输入定向到该虚拟机，请将鼠标指针移入其中或按 Ctrl+G。

#### 5.5 Test with iperf

- Set n0 as TCP Server, the port number is 5003

```

Client - VMware Workstation
Feb 8 19:03 node3@nf9:~ ping 10.0.15.3
64 bytes from 10.0.15.3: icmp_seq=13 ttl=63 time=0.881 ms
64 bytes from 10.0.15.3: icmp_seq=14 ttl=63 time=0.902 ms
64 bytes from 10.0.15.3: icmp_seq=15 ttl=63 time=1.00 ms

[2]+ Stopped ping 10.0.15.3
[team-8:n0 ~] ping $n1
PING 10.0.13.3 (10.0.13.3) 56(84) bytes of data.
64 bytes from 10.0.13.3: icmp_seq=1 ttl=63 time=2.17 ms
64 bytes from 10.0.13.3: icmp_seq=2 ttl=63 time=0.999 ms
64 bytes from 10.0.13.3: icmp_seq=3 ttl=63 time=0.989 ms
64 bytes from 10.0.13.3: icmp_seq=4 ttl=63 time=0.866 ms

[3]+ Stopped ping $n2
[team-8:n0 ~] ping $n2
PING 10.0.14.3 (10.0.14.3) 56(84) bytes of data.
64 bytes from 10.0.14.3: icmp_seq=1 ttl=63 time=2.16 ms
64 bytes from 10.0.14.3: icmp_seq=2 ttl=63 time=1.07 ms

[4]+ Stopped ping $n3
[team-8:n0 ~] ping $n3
PING 10.0.15.3 (10.0.15.3) 56(84) bytes of data.
64 bytes from 10.0.15.3: icmp_seq=1 ttl=63 time=1.06 ms
64 bytes from 10.0.15.3: icmp_seq=2 ttl=63 time=0.973 ms
64 bytes from 10.0.15.3: icmp_seq=3 ttl=63 time=0.978 ms

[5]+ Stopped iperf -s -p 5003
[team-8:n0 ~] iperf -s -p 5003
Server listening on TCP port 5003
TCP window size: 128 KByte (default)

```

- Set n1, n2, n3 as TCP Client, and set connection with the server n0 via port 5003

```

Client - VMware Workstation
Feb 8 19:57 node3@nf9:~ iperf -s -p 5003
Last login: Sat Feb 8 11:25:33 2025 from 10.48.160.137
[team-8:n0 ~] iperf -s -p 5003
Server listening on TCP port 5003
TCP window size: 128 KByte (default)

[ 4] local 10.0.12.3 port 5003 connected with 10.0.13.3 port 35665
[ ID] Interval Transfer Bandwidth
[ 4] 0.0-10.1 sec 114 MBytes 94.3 Mbits/sec
[ 5] local 10.0.12.3 port 5003 connected with 10.0.14.3 port 34320
[ 5] 0.0-10.1 sec 116 MBytes 96.5 Mbits/sec
[ 4] local 10.0.12.3 port 5003 connected with 10.0.15.3 port 48321
[ 4] 0.0-10.1 sec 108 MBytes 89.9 Mbits/sec

```

Server	Client	Protocol	Bandwidth (Mbits/sec)
n0	n1	TCP	94.3
n0	n2	TCP	96.5
n0	n3	TCP	89.9

## 5.6 Test iperf with script

- n0 as TCP server

```
Last login: Sat Feb 8 11:25:33 2025 from 10.48.160.137
[team-8:n0 ~] iperf -s -p 5003
-----
Server listening on TCP port 5003
TCP window size: 128 KByte (default)
[  4] local 10.0.12.3 port 5003 connected with 10.0.13.3 port 35665
[ ID] Interval      Transfer     Bandwidth
[  4] 0.0-10.1 sec   114 MBytes  94.3 Mbit/sec
[  5] local 10.0.12.3 port 5003 connected with 10.0.14.3 port 34320
[  5] 0.0-10.1 sec   116 MBytes  96.5 Mbit/sec
[  4] local 10.0.12.3 port 5003 connected with 10.0.15.3 port 48321
[  4] 0.0-10.1 sec   108 MBytes  89.9 Mbit/sec
```

- n1 as TCP server

```
Last login: Sat Feb 8 11:29:24 2025 from 10.48.160.137
[team-8:n1 ~] iperf -c Sn0 -p 5003
-----
Client connecting to 10.0.12.3, TCP port 5003
TCP window size: 16.0 KByte (default)
[  3] local 10.0.13.3 port 35665 connected with 10.0.12.3 port 5003
[ ID] Interval      Transfer     Bandwidth
[  3] 0.0-10.0 sec   114 MBytes  95.1 Mbit/sec
[team-8:n1 ~] iperf -s -p 5004
-----
Server listening on TCP port 5004
TCP window size: 128 KByte (default)
[  4] local 10.0.13.3 port 5004 connected with 10.0.12.3 port 39169
[ ID] Interval      Transfer     Bandwidth
[  4] 0.0-10.1 sec   113 MBytes  93.9 Mbit/sec
[  5] local 10.0.13.3 port 5004 connected with 10.0.14.3 port 35745
[  5] 0.0-10.1 sec   111 MBytes  92.1 Mbit/sec
[  4] local 10.0.13.3 port 5004 connected with 10.0.15.3 port 56447
[  4] 0.0-10.4 sec   113 MBytes  91.5 Mbit/sec
```

- n2 as TCP server

```

Feb 8 20:08
node3@nf6:~

Last login: Sat Feb  8 11:10:43 2025 from 10.48.160.137
[team-8:n2 ~] iperf -c $n0 -p 5003
-----
Client connecting to 10.0.12.3, TCP port 5003
TCP window size: 16.0 KByte (default)
-----
[  3] local 10.0.14.3 port 34320 connected with 10.0.12.3 port 5003
[ ID] Interval      Transfer     Bandwidth
[  3] 0.0-10.0 sec   116 MBytes  97.4 Mbits/sec
[team-8:n2 ~] iperf -c $n1 -p 5004
-----
Client connecting to 10.0.13.3, TCP port 5004
TCP window size: 16.0 KByte (default)
-----
[  3] local 10.0.14.3 port 35745 connected with 10.0.13.3 port 5004
[ ID] Interval      Transfer     Bandwidth
[  3] 0.0-10.0 sec   111 MBytes  92.9 Mbits/sec
[team-8:n2 ~] iperf -s -p 5005
-----
Server listening on TCP port 5005
TCP window size: 128 KByte (default)
-----
[  4] local 10.0.14.3 port 5005 connected with 10.0.12.3 port 48788
[ ID] Interval      Transfer     Bandwidth
[  4] 0.0-10.1 sec   115 MBytes  95.3 Mbits/sec
[  5] local 10.0.14.3 port 5005 connected with 10.0.13.3 port 42310
[  5] 0.0-10.1 sec   113 MBytes  93.8 Mbits/sec
[  4] local 10.0.14.3 port 5005 connected with 10.0.15.3 port 39928
[  4] 0.0-10.1 sec   117 MBytes  97.4 Mbits/sec

```

- n3 as TCP server

```

Feb 8 20:10
node3@nf7:~

[  3] 0.0-10.0 sec   108 MBytes  90.7 Mbits/sec
[team-8:n3 ~] iperf -c $n1 -p 5004
-----
Client connecting to 10.0.13.3, TCP port 5004
TCP window size: 16.0 KByte (default)
-----
[  3] local 10.0.15.3 port 56447 connected with 10.0.13.3 port 5004
[ ID] Interval      Transfer     Bandwidth
[  3] 0.0-10.0 sec   113 MBytes  94.5 Mbits/sec
[team-8:n3 ~] iperf -c $n2 -p 5005
-----
Client connecting to 10.0.14.3, TCP port 5005
TCP window size: 16.0 KByte (default)
-----
[  3] local 10.0.15.3 port 39928 connected with 10.0.14.3 port 5005
[ ID] Interval      Transfer     Bandwidth
[  3] 0.0-10.0 sec   117 MBytes  98.2 Mbits/sec
[team-8:n3 ~] -iperf -s -p 5006
-bash: -iperf: command not found
[team-8:n3 ~] iperf -s -p 5006
-----
Server listening on TCP port 5006
TCP window size: 128 KByte (default)
-----
[  4] local 10.0.15.3 port 5006 connected with 10.0.12.3 port 33248
[ ID] Interval      Transfer     Bandwidth
[  4] 0.0-10.1 sec   109 MBytes  90.3 Mbits/sec
[  5] local 10.0.15.3 port 5006 connected with 10.0.13.3 port 41299
[  5] 0.0-10.1 sec   112 MBytes  93.3 Mbits/sec
[  4] local 10.0.15.3 port 5006 connected with 10.0.14.3 port 58261
[  4] 0.0-10.1 sec   115 MBytes  95.5 Mbits/sec

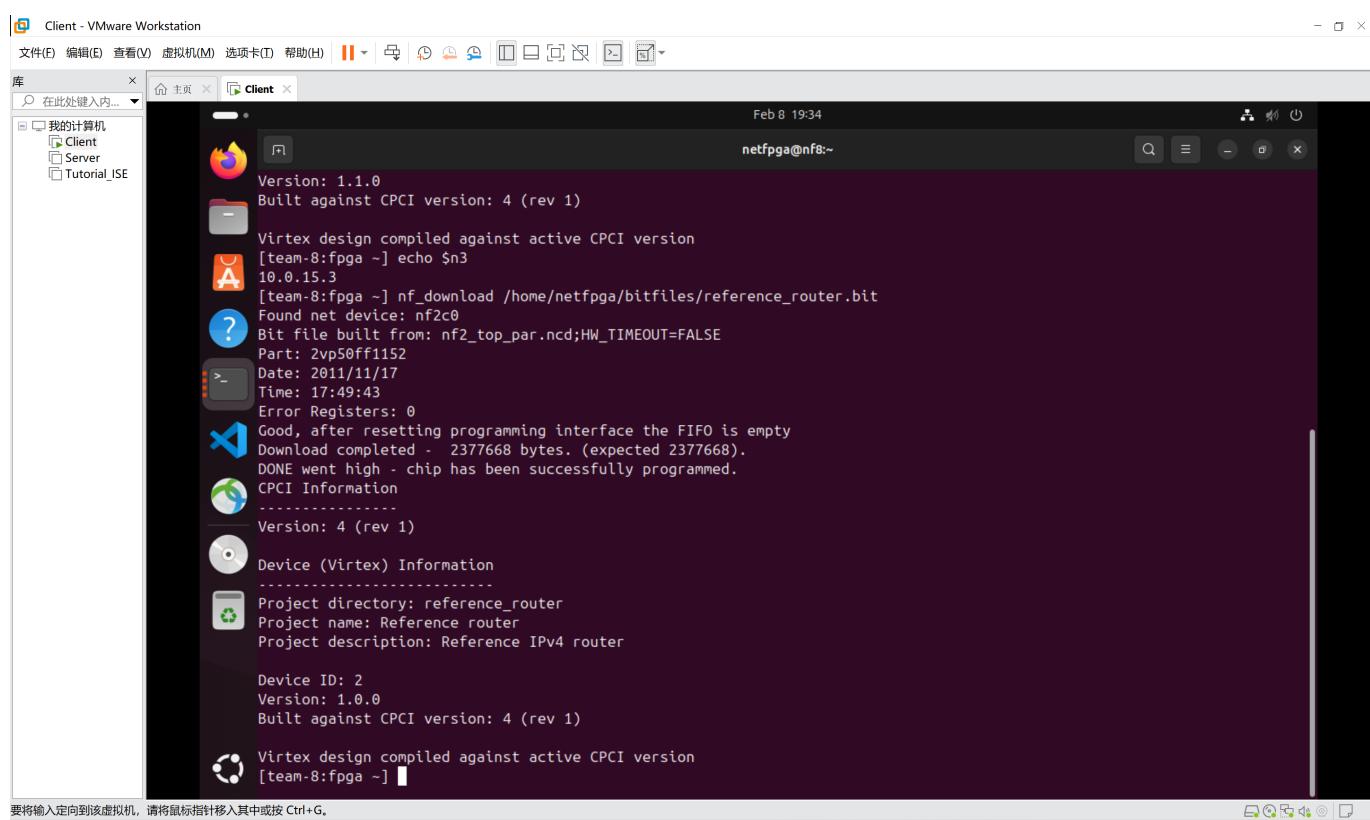
```

<b>Server</b>	<b>Client</b>	<b>Protocol</b>	<b>Bandwidth (Mbit/sec)</b>
n0	n1	TCP	94.3
n0	n2	TCP	96.5
n0	n3	TCP	89.9

Server	Client	Protocol	Bandwidth (Mbits/sec)
n1	n0	TCP	93.9
n1	n2	TCP	92.1
n1	n3	TCP	91.5
n2	n0	TCP	95.3
n2	n1	TCP	93.8
n2	n3	TCP	97.4
n3	n0	TCP	90.3
n3	n1	TCP	93.3
n3	n2	TCP	95.5

## 6. NetFPGA Hardware IP Router

## 6.1 Download reference router into NetFPGA



## 6.2 Check PID and Kill

```

Virtex design compiled against active CPCI version
[team-8:fpga ~] nf_download /home/netfpga/bitfiles/reference_router.bit
Found net device: nf2c0
Bit file built from: nf2_top_par.ncd;HW_TIMEOUT=FALSE
Part: 2vp50ff1152
Date: 2011/11/17
Time: 17:49:43
Error Registers: 0
Good, after resetting programming interface the FIFO is empty
Download completed - 2377668 bytes. (expected 2377668).
DONE went high - chip has been successfully programmed.
CPCI Information
-----
Version: 4 (rev 1)

Device (Virtex) Information
-----
Project directory: reference_router
Project name: Reference router
Project description: Reference IPv4 router

Device ID: 2
Version: 1.0.0
Built against CPCI version: 4 (rev 1)

Virtex design compiled against active CPCI version
[team-8:fpga ~] rkd &
[1] 30554
[team-8:fpga ~] kill 30554
[1]+ Terminated rkd
[team-8:fpga ~]

```

## 6.3 Re-Run the iperf with reference\_router.bit and check Bandwidth

- n0 as TCP server

```

[ 3] local 10.0.12.3 port 39169 connected with 10.0.13.3 port 5004
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 113 MBytes 94.8 Mbits/sec
[team-8:n0 ~] iperf -c Sn2 -p 5005
-----
Client connecting to 10.0.14.3, TCP port 5005
TCP window size: 16.0 KByte (default)
[ 3] local 10.0.12.3 port 48788 connected with 10.0.14.3 port 5005
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 115 MBytes 96.1 Mbits/sec
[team-8:n0 ~] iperf -c Sn3 -p 5006
-----
Client connecting to 10.0.15.3, TCP port 5006
TCP window size: 16.0 KByte (default)
[ 3] local 10.0.12.3 port 33248 connected with 10.0.15.3 port 5006
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 109 MBytes 91.0 Mbits/sec
[team-8:n0 ~] iperf -s -p 5000
-----
Server listening on TCP port 5000
TCP window size: 128 KByte (default)
[ 4] local 10.0.12.3 port 5000 connected with 10.0.13.3 port 57571
[ ID] Interval Transfer Bandwidth
[ 4] 0.0-10.1 sec 453 MBytes 378 Mbits/sec
[ 5] local 10.0.12.3 port 5000 connected with 10.0.14.3 port 42502
[ 5] 0.0-10.0 sec 446 MBytes 373 Mbits/sec
[ 4] local 10.0.12.3 port 5000 connected with 10.0.15.3 port 35179
[ 4] 0.0-10.0 sec 445 MBytes 372 Mbits/sec

```

- n1 as TCP server

Client - VMware Workstation

文件(E) 编辑(E) 查看(V) 虚拟机(M) 选项卡(I) 帮助(H) || 截屏 拷贝 剪切 复制 粘贴 剪切板

库 在此处键入内... Client

我的计算机 Client Server Tutorial\_ISE

```
Feb 8 20:19
node3@nfs:~ [ 3] local 10.0.13.3 port 42310 connected with 10.0.14.3 port 5005
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 113 MBytes 94.7 Mbits/sec
[team-8:n1 ~] iperf -c $n3 -p 5006
-----
[A] Client connecting to 10.0.15.3, TCP port 5006
TCP window size: 16.0 KByte (default)
[ 3] local 10.0.13.3 port 41299 connected with 10.0.15.3 port 5006
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 112 MBytes 93.8 Mbits/sec
[team-8:n1 ~] iperf -c $n0 -p 5000
-----
[?] Client connecting to 10.0.12.3, TCP port 5000
TCP window size: 16.0 KByte (default)
[ 3] local 10.0.13.3 port 57571 connected with 10.0.12.3 port 5000
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 453 MBytes 380 Mbits/sec
[team-8:n1 ~] iperf -s -p 5001
-----
[CD] Server listening on TCP port 5001
TCP window size: 128 KByte (default)
[ 4] local 10.0.13.3 port 5001 connected with 10.0.12.3 port 38671
[ ID] Interval Transfer Bandwidth
[ 4] 0.0-10.0 sec 428 MBytes 357 Mbits/sec
[ 5] local 10.0.13.3 port 5001 connected with 10.0.14.3 port 40500
[ 4] local 10.0.13.3 port 5001 connected with 10.0.15.3 port 42724
[ 5] 0.0-10.0 sec 536 MBytes 449 Mbits/sec
[ 4] 0.0-10.0 sec 417 MBytes 349 Mbits/sec
```

- n2 as TCP server

```
[ 3] local 10.0.14.3 port 58261 connected with 10.0.15.3 port 5006
[ ID] Interval      Transfer     Bandwidth
[ 3]  0.0-10.0 sec   115 MBytes  96.3 Mbits/sec
[team-8:n2 ~] iperf -c $n0 -p 5000

Client connecting to 10.0.12.3, TCP port 5000
TCP window size: 16.0 KByte (default)

[ 3] local 10.0.14.3 port 42502 connected with 10.0.12.3 port 5000
[ ID] Interval      Transfer     Bandwidth
[ 3]  0.0-10.0 sec   446 MBytes  374 Mbits/sec
[team-8:n2 ~] iperf -c $n1 -p 5001

Client connecting to 10.0.13.3, TCP port 5001
TCP window size: 18.3 KByte (default)

[ 3] local 10.0.14.3 port 40500 connected with 10.0.13.3 port 5001
[ ID] Interval      Transfer     Bandwidth
[ 3]  0.0-10.0 sec   536 MBytes  450 Mbits/sec
[team-8:n2 ~] iperf -s -p 5002

Server listening on TCP port 5002
TCP window size: 128 KByte (default)

[ 4] local 10.0.14.3 port 5002 connected with 10.0.12.3 port 49265
[ ID] Interval      Transfer     Bandwidth
[ 4]  0.0-10.0 sec   423 MBytes  354 Mbits/sec
[ 5] local 10.0.14.3 port 5002 connected with 10.0.13.3 port 38226
[ 5]  0.0-10.0 sec   524 MBytes  439 Mbits/sec
[ 4] local 10.0.14.3 port 5002 connected with 10.0.15.3 port 60644
[ 4]  0.0-10.0 sec   423 MBytes  354 Mbits/sec
```

- n3 as TCP server

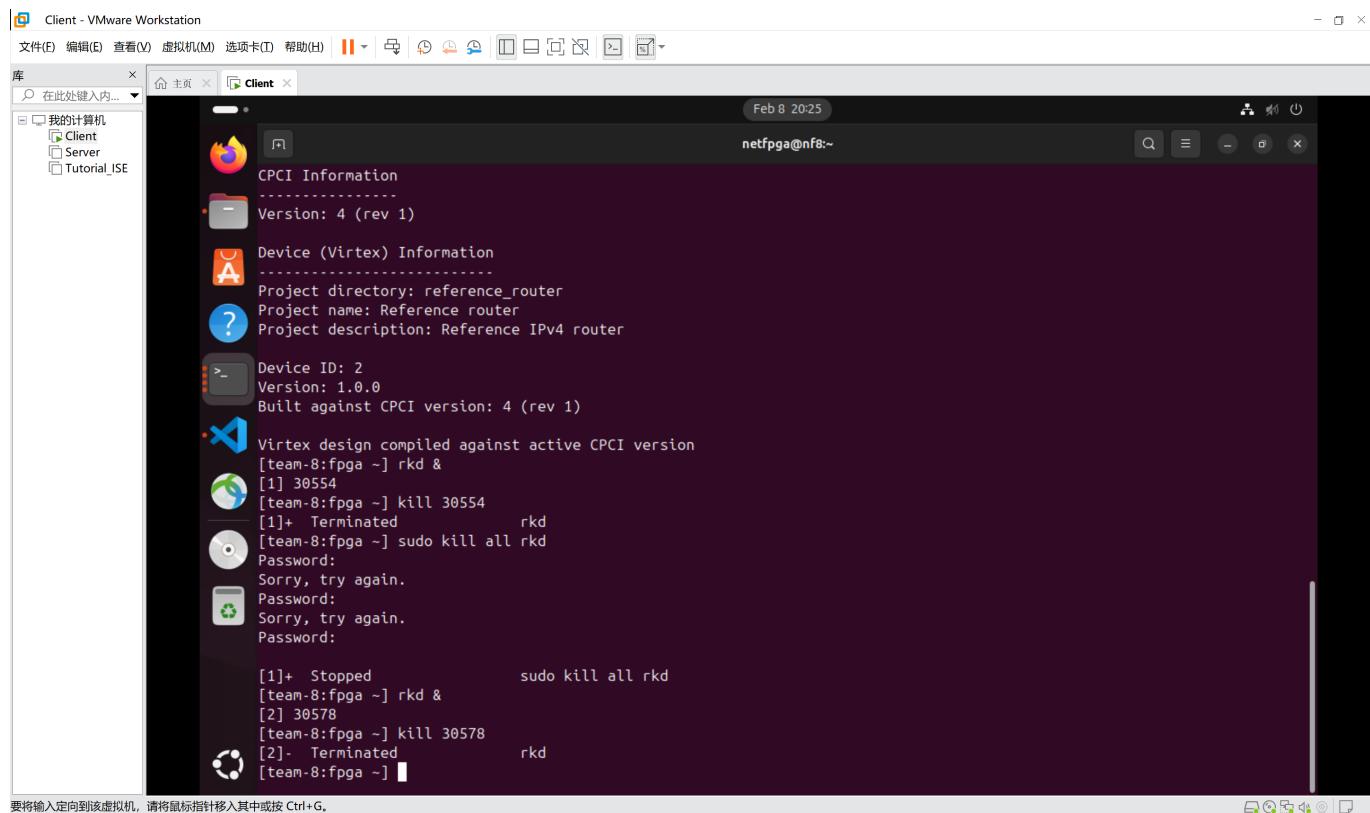
<b>Server</b>	<b>Client</b>	<b>Protocol</b>	<b>Bandwidth (Mbits/sec)</b>
n0	n1	TCP	378
n0	n2	TCP	373
n0	n3	TCP	372
n1	n0	TCP	357
n1	n2	TCP	449
n1	n3	TCP	349
n2	n0	TCP	354
n2	n1	TCP	439
n2	n3	TCP	354
n3	n0	TCP	320
n3	n1	TCP	373
n3	n2	TCP	359

- Has the bandwidth changed? If so, why?

we can see that the bandwidth went up by a lot, and that we guess the reason could be that since the netfpga now already knows about the routes and configurations, it would make sending packages between each nodes much quicker since it doesn't have to sent the header to all the nodes and wait for the right nodes to response, hence the latency and bandwidth could improve, and therefore the speed improvements

## 6.4 Re-Run the iperf with reference\_nic.bit and check Bandwidth

- Kill rkd & download reference\_nic.bit



```

Client - VMware Workstation
Feb 8 20:25 netfpga@nf8:~>

CPCI Information
Version: 4 (rev 1)

Device (Virtex) Information
Project directory: reference_router
Project name: Reference router
Project description: Reference IPv4 router

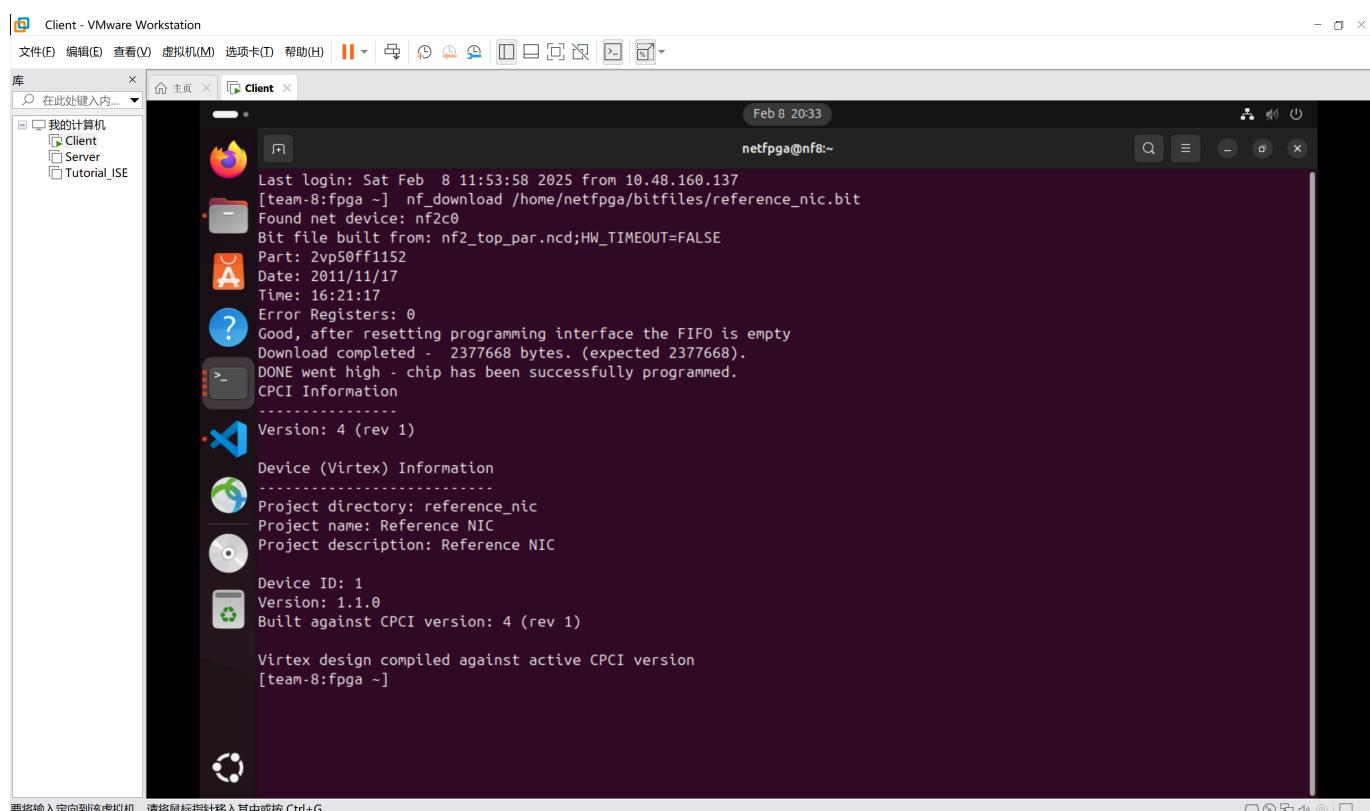
Device ID: 2
Version: 1.0.0
Built against CPCI version: 4 (rev 1)

Virtex design compiled against active CPCI version
[team-8:fpga ~] rkd &
[1] 30554
[team-8:fpga ~] kill 30554
[1]+ Terminated rkd
[team-8:fpga ~] sudo kill all rkd
Password:
Sorry, try again.
Password:
Sorry, try again.
Password:

[1]+ Stopped sudo kill all rkd
[team-8:fpga ~] rkd &
[2] 30578
[team-8:fpga ~] kill 30578
[2]- Terminated rkd
[team-8:fpga ~]

要将输入定向到该虚拟机，请将鼠标指针移入其中或按 Ctrl+G。

```



```

Client - VMware Workstation
Feb 8 20:33 netfpga@nf8:~

Last login: Sat Feb 8 11:53:58 2025 from 10.48.160.137
[team-8:fpga ~] nf_download /home/netfpga/bitfiles/reference_nic.bit
Found net device: nf2c0
Bit file built from: nf2_top_par.ncd;HW_TIMEOUT=FALSE
Part: 2vp50ff1152
Date: 2011/11/17
Time: 16:21:17
Error Registers: 0
Good, after resetting programming interface the FIFO is empty.
Download completed - 2377668 bytes. (expected 2377668).
DONE went high - chip has been successfully programmed.

CPCI Information
Version: 4 (rev 1)

Device (Virtex) Information
Project directory: reference_nic
Project name: Reference NIC
Project description: Reference NIC

Device ID: 1
Version: 1.1.0
Built against CPCI version: 4 (rev 1)

Virtex design compiled against active CPCI version
[team-8:fpga ~]

要将输入定向到该虚拟机，请将鼠标指针移入其中或按 Ctrl+G。

```

- n0 as UDP server

```

Feb 8 20:32
node3@nfs:~>

Last login: Sat Feb 8 11:42:11 2025 from 10.48.160.137
[team-8:n0 ~] iperf -s -u
-----
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 2.00 MByte (default)

[ 3] local 10.0.12.3 port 5001 connected with 10.0.13.3 port 42172
[ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.050 ms 0/ 893 (0%)
[ 4] local 10.0.12.3 port 5001 connected with 10.0.14.3 port 50838
[ 4] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.057 ms 0/ 893 (0%)
[ 3] local 10.0.12.3 port 5001 connected with 10.0.15.3 port 55389
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.065 ms 0/ 893 (0%)

```

- n1 as UDP server

```

Feb 8 20:51
node3@nfs:~>

Last login: Sat Feb 8 11:46:02 2025 from 10.48.160.137
[team-8:n1 ~] iperf -c $n0 ip 5001
iperf: ignoring extra argument -- ip
iperf: ignoring extra argument -- 5001
connect failed: Connection refused
[team-8:n1 ~] iperf -u -c $n0 -p 5001
-----
Client connecting to 10.0.12.3, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 2.00 MByte (default)

[ 3] local 10.0.13.3 port 42172 connected with 10.0.12.3 port 5001
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec
[ 3] Sent 893 datagrams
[ 3] Server Report:
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.049 ms 0/ 893 (0%)
[team-8:n1 ~] iperf -u -s -p 5001
-----
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 2.00 MByte (default)

[ 3] local 10.0.13.3 port 5001 connected with 10.0.12.3 port 39000
[ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.067 ms 0/ 893 (0%)
[ 4] local 10.0.13.3 port 5001 connected with 10.0.14.3 port 33618
[ 4] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.076 ms 0/ 893 (0%)
[ 3] local 10.0.13.3 port 5001 connected with 10.0.15.3 port 56617
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.099 ms 0/ 893 (0%)

```

- n2 as UDP server

```

Feb 8 20:53
node3@nf6:~>

[ 3] local 10.0.14.3 port 50838 connected with 10.0.12.3 port 5001
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec
[ 3] Sent 893 datagrams
[ 3] Server Report:
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.056 ms 0/ 893 (0%)
[team-8:n2 -] iperf -u -c $n1 -p 5001
-----
Client connecting to 10.0.13.3, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 2.00 MByte (default)

[ 3] local 10.0.14.3 port 33618 connected with 10.0.13.3 port 5001
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec
[ 3] Sent 893 datagrams
[ 3] Server Report:
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.076 ms 0/ 893 (0%)
[team-8:n2 -] iperf -u -s -p 5002
-----
Server listening on UDP port 5002
Receiving 1470 byte datagrams
UDP buffer size: 2.00 MByte (default)

[ 3] local 10.0.14.3 port 5002 connected with 10.0.12.3 port 56788
[ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.085 ms 0/ 893 (0%)
[ 4] local 10.0.14.3 port 5002 connected with 10.0.13.3 port 50765
[ 4] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.084 ms 0/ 893 (0%)
[ 3] local 10.0.14.3 port 5002 connected with 10.0.15.3 port 51984
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.101 ms 0/ 893 (0%)

```

- n3 as UDP server

```

Feb 8 20:55
node3@nf7:~>

[ 3] local 10.0.15.3 port 56617 connected with 10.0.13.3 port 5001
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec
[ 3] Sent 893 datagrams
[ 3] Server Report:
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.098 ms 0/ 893 (0%)
[team-8:n3 -] iperf -u -c $n2 -p 5002
-----
Client connecting to 10.0.14.3, UDP port 5002
Sending 1470 byte datagrams
UDP buffer size: 2.00 MByte (default)

[ 3] local 10.0.15.3 port 51984 connected with 10.0.14.3 port 5002
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec
[ 3] Sent 893 datagrams
[ 3] Server Report:
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.100 ms 0/ 893 (0%)
[team-8:n3 -] iperf -u -s -p 5003
-----
Server listening on UDP port 5003
Receiving 1470 byte datagrams
UDP buffer size: 2.00 MByte (default)

[ 3] local 10.0.15.3 port 5003 connected with 10.0.12.3 port 42521
[ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.104 ms 0/ 893 (0%)
[ 4] local 10.0.15.3 port 5003 connected with 10.0.13.3 port 36704
[ 4] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.109 ms 0/ 893 (0%)
[ 3] local 10.0.15.3 port 5003 connected with 10.0.14.3 port 44384
[ 3] 0.0-10.0 sec 1.25 MBytes 1.05 Mbits/sec 0.132 ms 0/ 893 (0%)

```

Server	Client	Protocol	Bandwidth (Mbit/sec)
n0	n1	UDP	1.05
n0	n2	UDP	1.05
n0	n3	UDP	1.05

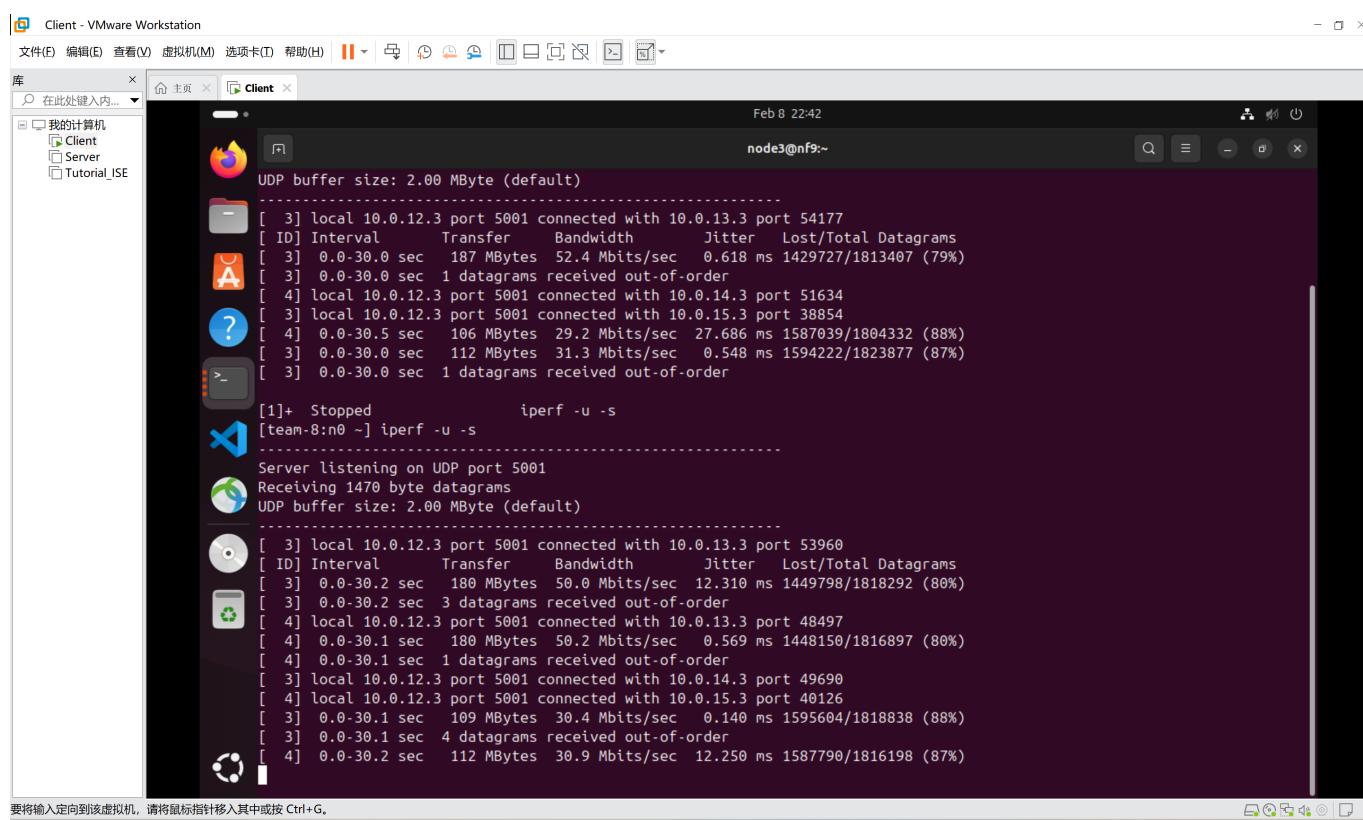
<b>Server</b>	<b>Client</b>	<b>Protocol</b>	<b>Bandwidth (Mbits/sec)</b>
n1	n0	UDP	1.05
n1	n2	UDP	1.05
n1	n3	UDP	1.05
n2	n0	UDP	1.05
n2	n1	UDP	1.05
n2	n3	UDP	1.05
n3	n0	UDP	1.05
n3	n1	UDP	1.05
n3	n2	UDP	1.05

- Why does using small packets stress the system?

Using small packets means that the router has to put more efforts in analysing each packet's header to decide where to sent them, and since every packet is very small in size, the total bandwidth would be limited by the amount of packet header the router could process every second.

## 6.5 Testing bidir UDP on each node

- n0 as UDP server



- n1 as UDP server

```

Feb 8 22:45
node3@nfs:~>

[ 3] 0.0-30.2 sec 180 MBytes 50.0 Mbits/sec 12.310 ms 1449798/1818292 (80%)
[ 3] 0.0-30.2 sec 3 datagrams received out-of-order
[team-8:n1 -] iperf -u -c $n0 -bidir -p 5001 -b 1G -l 512 -t 30
-----
Client connecting to 10.0.12.3, UDP port 5001
Sending 512 byte datagrams
UDP buffer size: 2.00 MByte (default)

[ 3] local 10.0.13.3 port 48497 connected with 10.0.12.3 port 5001
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-30.0 sec 887 MBytes 248 Mbits/sec
[ 3] Sent 1816898 datagrams
[ 3] Server Report:
[ 3] 0.0-30.1 sec 180 MBytes 50.2 Mbits/sec 0.568 ms 1448150/1816897 (80%)
[ 3] 0.0-30.1 sec 1 datagrams received out-of-order
[team-8:n1 -] iperf -u -s
-----
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 2.00 MByte (default)

[ 3] local 10.0.13.3 port 5001 connected with 10.0.12.3 port 48259
[ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[ 3] 0.0-30.0 sec 165 MBytes 46.0 Mbits/sec 0.643 ms 1481289/1818293 (81%)
[ 3] 0.0-30.0 sec 1 datagrams received out-of-order
[ 4] local 10.0.13.3 port 5001 connected with 10.0.14.3 port 50700
[ 3] local 10.0.13.3 port 5001 connected with 10.0.15.3 port 48527
[ 4] 0.0-30.1 sec 110 MBytes 30.7 Mbits/sec 12.261 ms 1593172/1818845 (88%)
[ 4] 0.0-30.1 sec 1 datagrams received out-of-order
[ 3] 0.0-30.2 sec 102 MBytes 28.2 Mbits/sec 11.923 ms 1603893/1812025 (89%)
[ 3] 0.0-30.2 sec 1 datagrams received out-of-order

```

要将输入定向到该虚拟机，请将鼠标指针移入其中或按 Ctrl+G。

- n2 as UDP server

```

Feb 8 22:47
node3@nf6:~>

[ 3] 0.0-30.0 sec 888 MBytes 248 Mbits/sec
[ 3] Sent 1818839 datagrams
[ 3] Server Report:
[ 3] 0.0-30.1 sec 109 MBytes 30.4 Mbits/sec 0.140 ms 1595604/1818838 (88%)
[ 3] 0.0-30.1 sec 4 datagrams received out-of-order
[team-8:n2 -] iperf -u -c $n1 -bidir -b 1G -l 512 -t 30
-----
Client connecting to 10.0.13.3, UDP port 5001
Sending 512 byte datagrams
UDP buffer size: 2.00 MByte (default)

[ 3] local 10.0.14.3 port 50700 connected with 10.0.13.3 port 5001
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-30.0 sec 888 MBytes 248 Mbits/sec
[ 3] Sent 1818853 datagrams
[ 3] Server Report:
[ 3] 0.0-30.1 sec 110 MBytes 30.7 Mbits/sec 12.260 ms 1593172/1818845 (88%)
[ 3] 0.0-30.1 sec 1 datagrams received out-of-order
[team-8:n2 -] iperf -u -s
-----
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 2.00 MByte (default)

[ 3] local 10.0.14.3 port 5001 connected with 10.0.12.3 port 47162
[ 4] local 10.0.14.3 port 5001 connected with 10.0.13.3 port 60110
[ 5] local 10.0.14.3 port 5001 connected with 10.0.15.3 port 40355
[ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[ 3] 0.0-31.0 sec 15.5 KBytes 4.10 Kbits/sec 0.130 ms 0/ 31 (0%)
[ 4] 0.0-31.7 sec 18.0 KBytes 4.65 Kbits/sec 0.077 ms 0/ 36 (0%)
[ 5] 0.0-31.7 sec 18.0 KBytes 4.65 Kbits/sec 0.047 ms 0/ 36 (0%)

```

要将输入定向到该虚拟机，请将鼠标指针移入其中或按 Ctrl+G。

- n3 as UDP server

```
[team8:n3 ~] iperf -u -c $n2 -t 30 -l 512 -b 1G -bidir
WARNING: delay too large, reducing from -2147.5 to 1.0 seconds.
nanosleep failed: Invalid argument
nanosleep failed: Invalid argument
nanosleep failed: Invalid argument
nanosleep failed: Invalid argument
-----
[ 3] Client connecting to 10.0.14.3, UDP port 5001
Sending 512 byte datagrams
UDP buffer size: 2.00 MByte (default)
[ 3] local 10.0.15.3 port 40355 connected with 10.0.14.3 port 5001
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-31.7 sec 18.0 KBytes 4.65 Kbits/sec
[ 3] Sent 36 datagrams
[ 3] Server Report:
[ 3] 0.0-31.7 sec 18.0 KBytes 4.65 Kbits/sec 0.046 ms 0/ 36 (0%)
[team8:n3 ~] iperf -u -s
-----
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 2.00 MByte (default)
[ 3] local 10.0.15.3 port 5001 connected with 10.0.12.3 port 46426
[ 4] local 10.0.15.3 port 5001 connected with 10.0.13.3 port 50162
[ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[ 3] 0.0-30.2 sec 223 MBytes 61.9 Mbits/sec 5.486 ms 1356998/1813406 (75%)
[ 5] local 10.0.15.3 port 5001 connected with 10.0.14.3 port 47949
[ 4] 0.0-30.0 sec 100 MBytes 28.0 Mbits/sec 0.061 ms 30487/235798 (13%)
[ 4] 0.0-30.0 sec 1 datagrams received out-of-order
[ 5] 0.0-30.3 sec 146 MBytes 40.4 Mbits/sec 11.107 ms 1512261/1810614 (84%)
```

We can see that the speed of the test did improve but did not reach a point that it uses all 4Gbps of bandwidth, so we don't think that its fair to say that the NetFPGA can route IP traffic bi-directionally at line speed for a total of 4Gbps of cross-wise bandwidth

## Extra. GitHub Link

- This Lab's update and commit history could be checked by the below link:
  - [https://github.com/yuezhenglingluan/USC\\_EE533\\_lab4.git](https://github.com/yuezhenglingluan/USC_EE533_lab4.git)