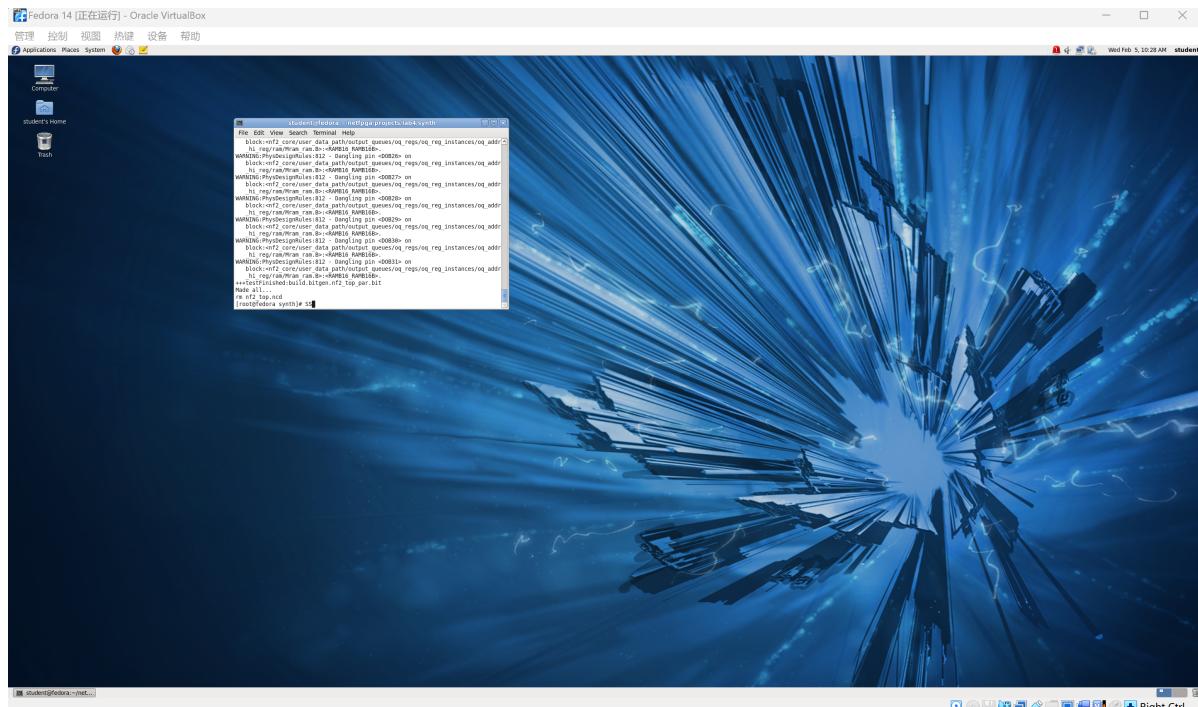


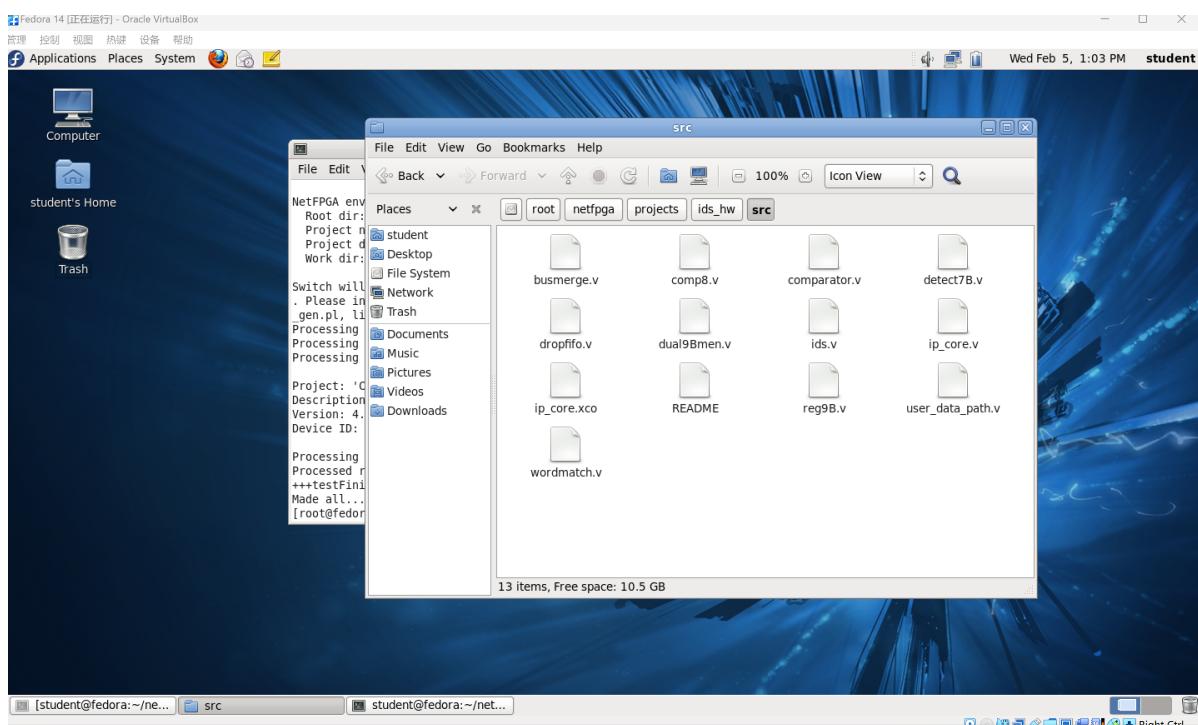
EE533_Lab4_Report

1. Download and Setup Fedora VM

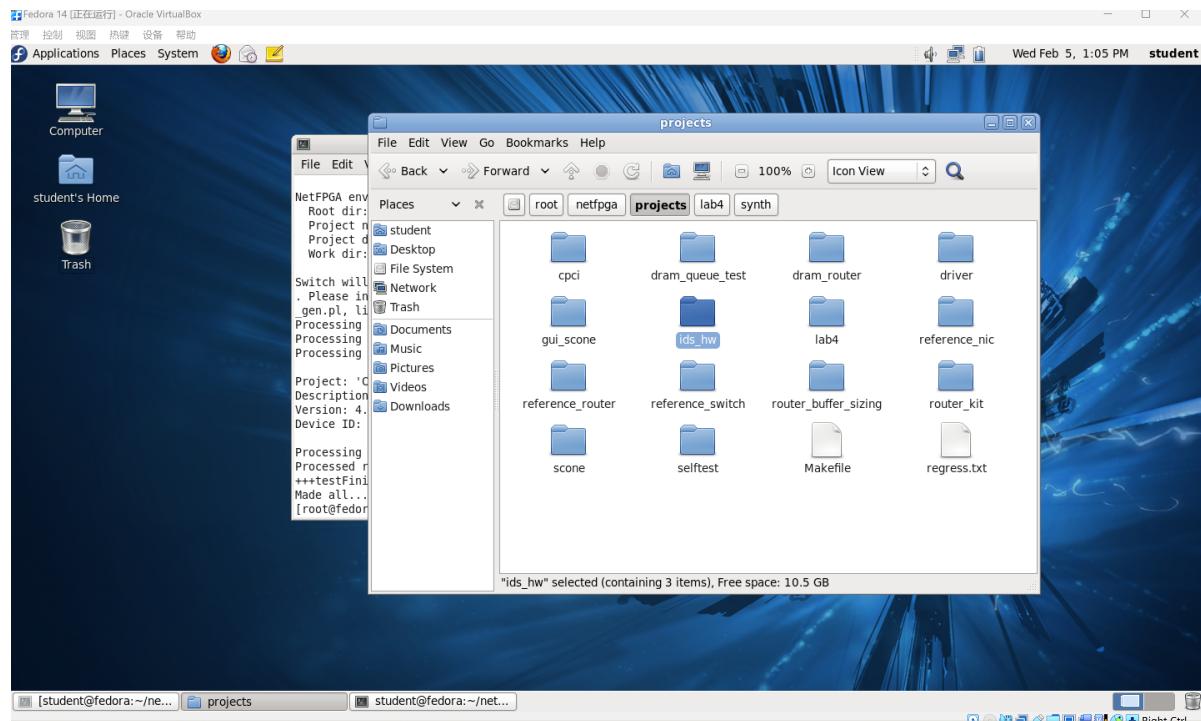


2. Compile and generate a design bitfile for NetFPGA

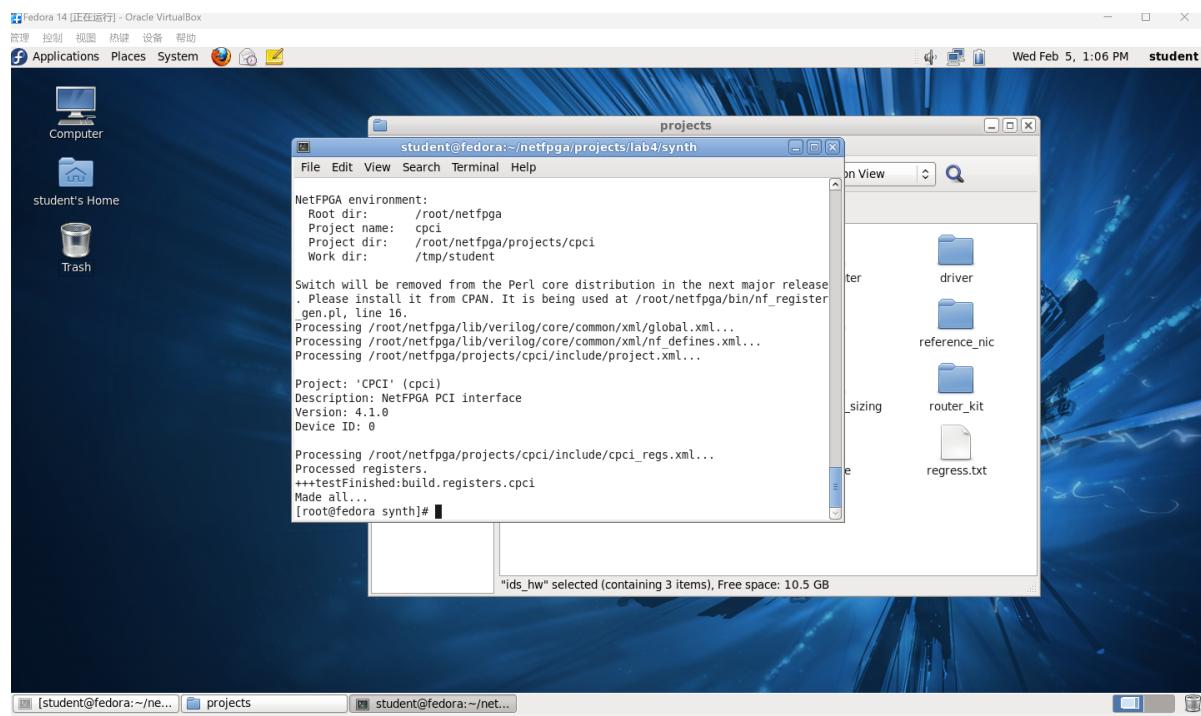
2.1 Extract ids_hw and copy all Verilog and ip core files into ids_hw/src



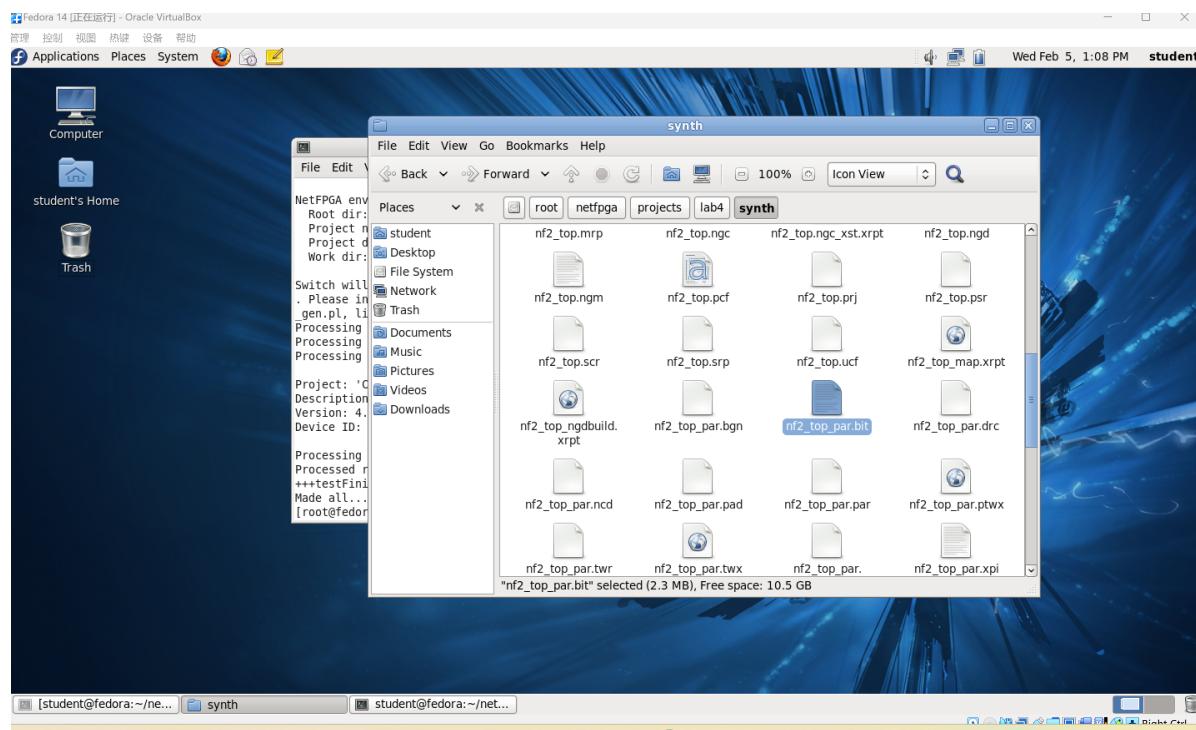
2.2 Copy all of source files within ids_hw into corresponding folders into NetFPGA project folder



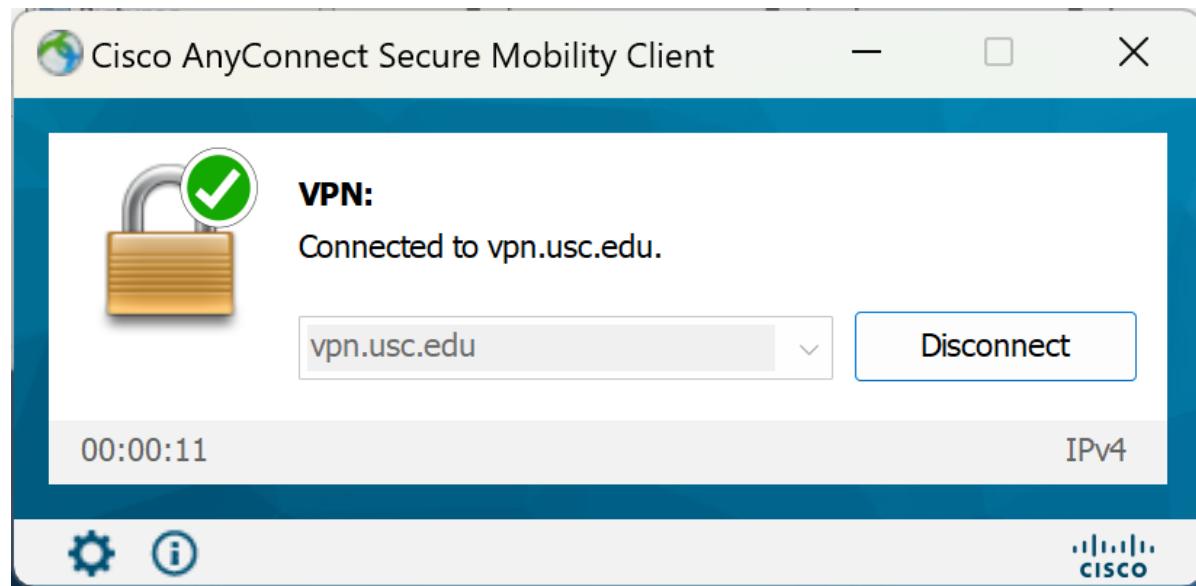
2.3 Compile the design by 'cd' into the synth folder type 'make'



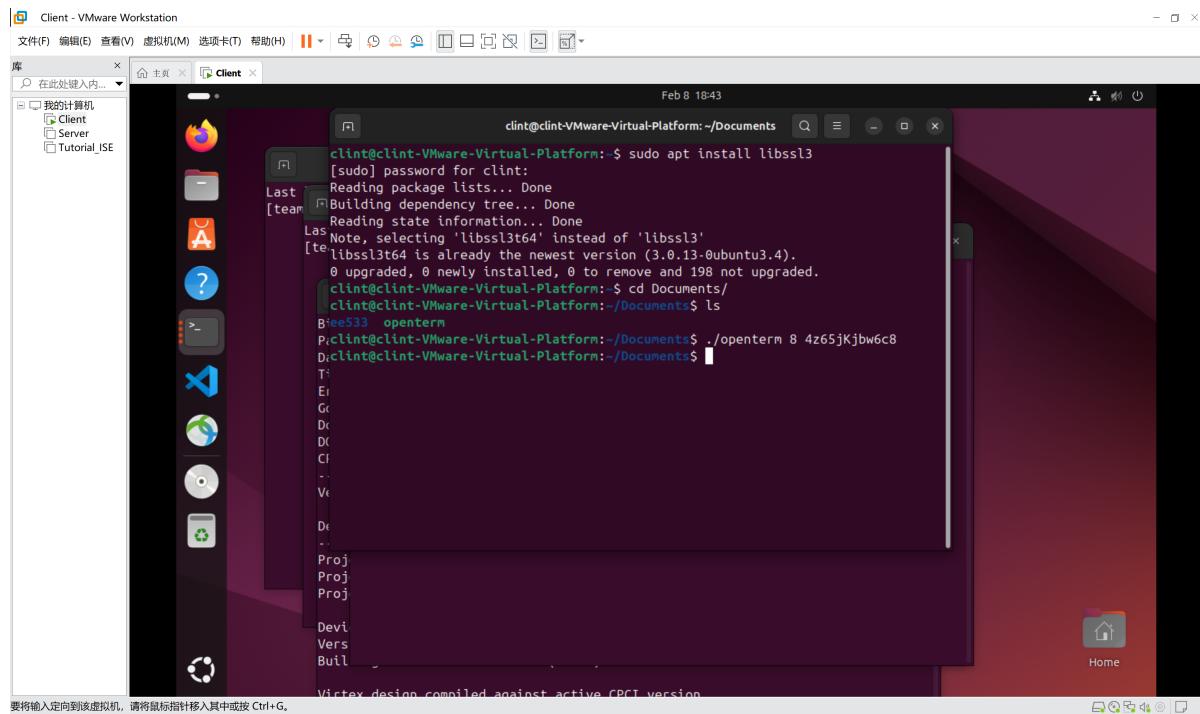
2.4 '*.bit' file generated



3. Set Up VPN to USC

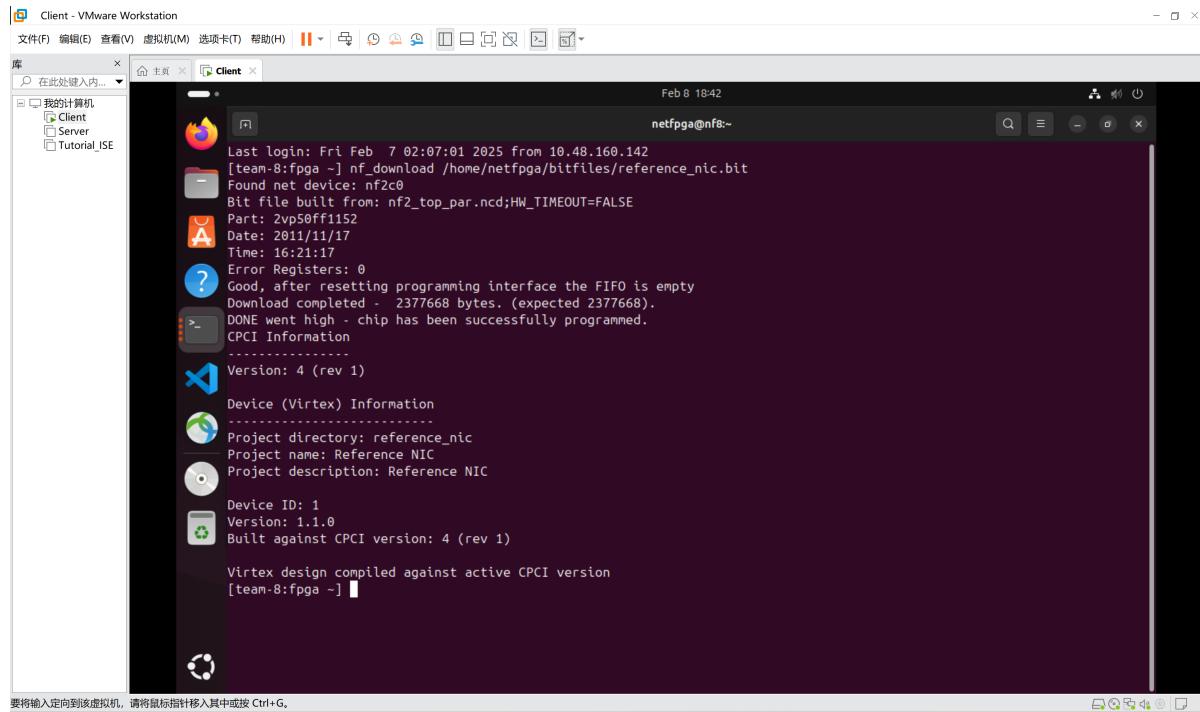


4. NetFPGA Environment

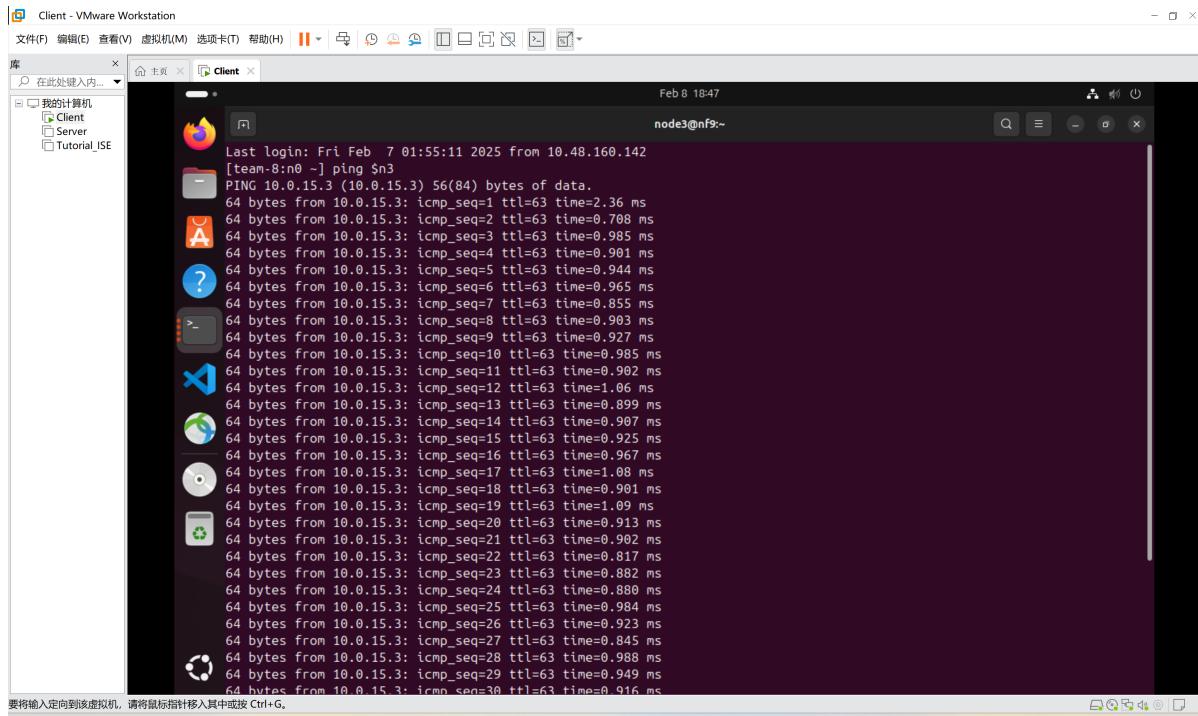


5. NetFPGA-based Linux Kernel IP Router

5.1 Test NetFPGA as network interface card



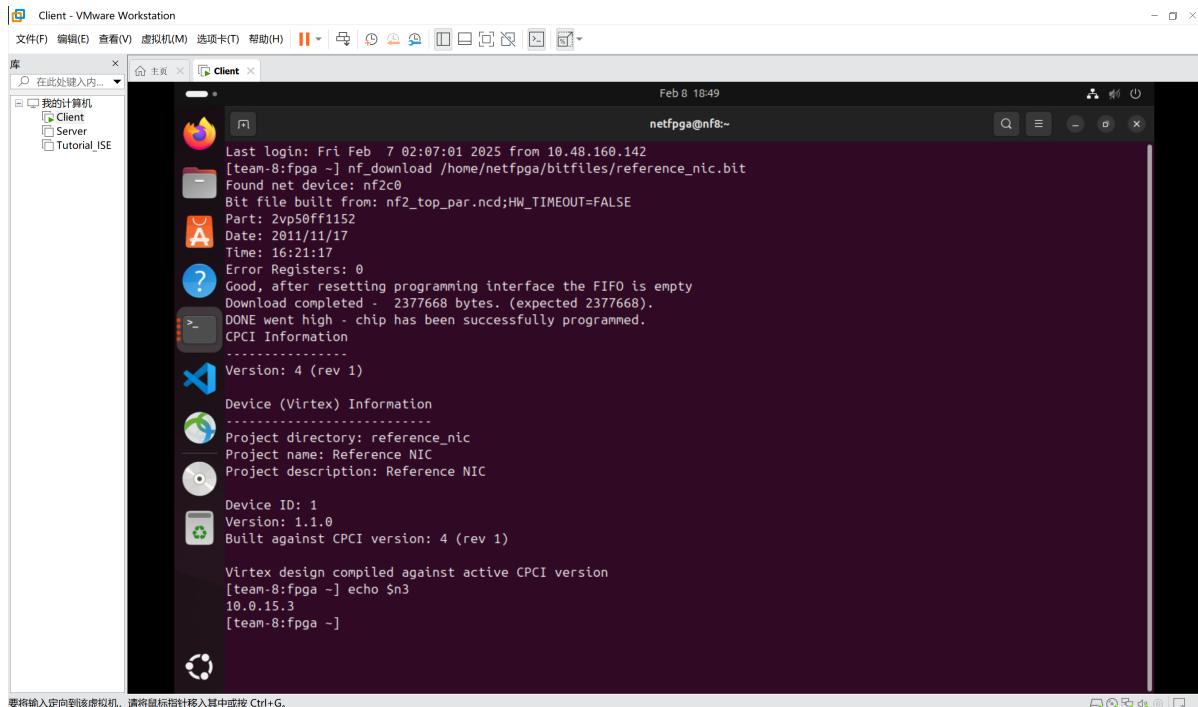
5.2 Test ping from n0 to n3



```
Last login: Fri Feb 7 01:55:11 2025 from 10.48.160.142
[team-8:n0 ~] ping Sn3
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 Sn3
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 ~]
```

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 Test Ping all other nodes from one to another

5.4.1 n0 -> n1, n2, n3

```
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

```
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 $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=1.38 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 $n2
[team-8:n1 ~] 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=1.43 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 $n3
[team-8:n1 ~]
```

5.4.3 n2 -> n0, n1, n3

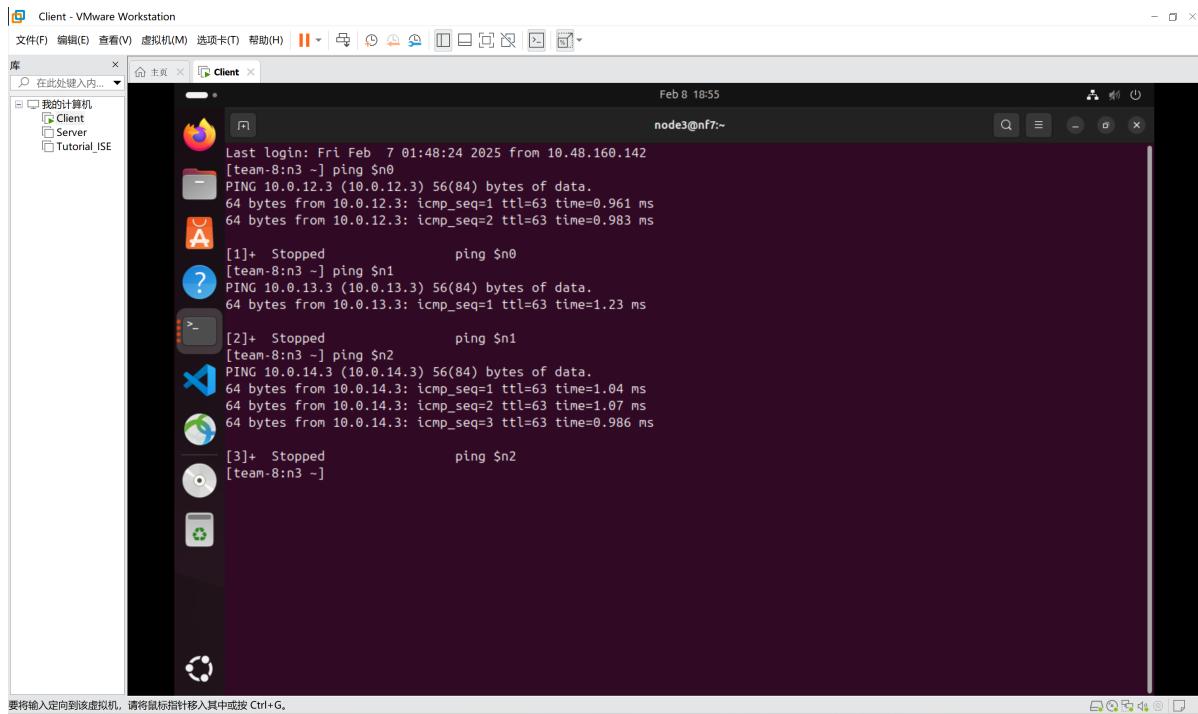
```
Last login: Fri Feb 7 01:40:28 2025 from 10.48.160.142
[team-8:n2 ~] ping $n0
PING 10.0.12.3 (10.0.12.3) 56(84) bytes of data.
64 bytes from 10.0.12.3: icmp_seq=1 ttl=63 time=0.884 ms
64 bytes from 10.0.12.3: icmp_seq=2 ttl=63 time=1.02 ms

[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 ~]
```

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

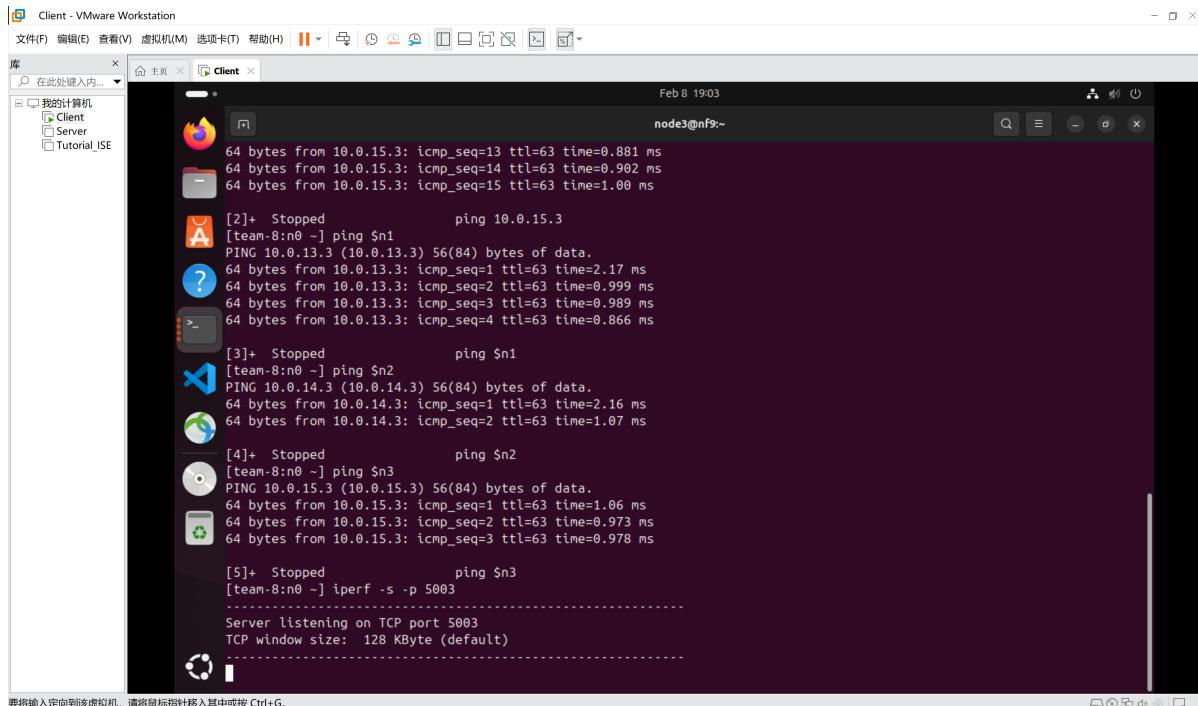
[1]+ Stopped ping $n0
[team-8:n3 ~] ping $n1
PING 10.0.13.3 (10.0.13.3) 56(84) bytes of data.
64 bytes from 10.0.13.3: icmp_seq=1 ttl=63 time=1.23 ms

[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 ~]
```

5.5 Test with iperf

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



```
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=0.992 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 ~] 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

The screenshot shows a Linux desktop environment with a terminal window open. The terminal title is "Client" and the window title is "Client". The terminal displays the output of an iperf test between two hosts. The host running the test (node3) is connected to three different hosts (10.0.12.3, 10.0.14.3, and 10.0.15.3) at various bandwidths (94.3 Mbit/sec, 96.5 Mbit/sec, and 89.9 Mbit/sec). The terminal interface includes a sidebar with icons for file operations and a status bar at the bottom.

```
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
```

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

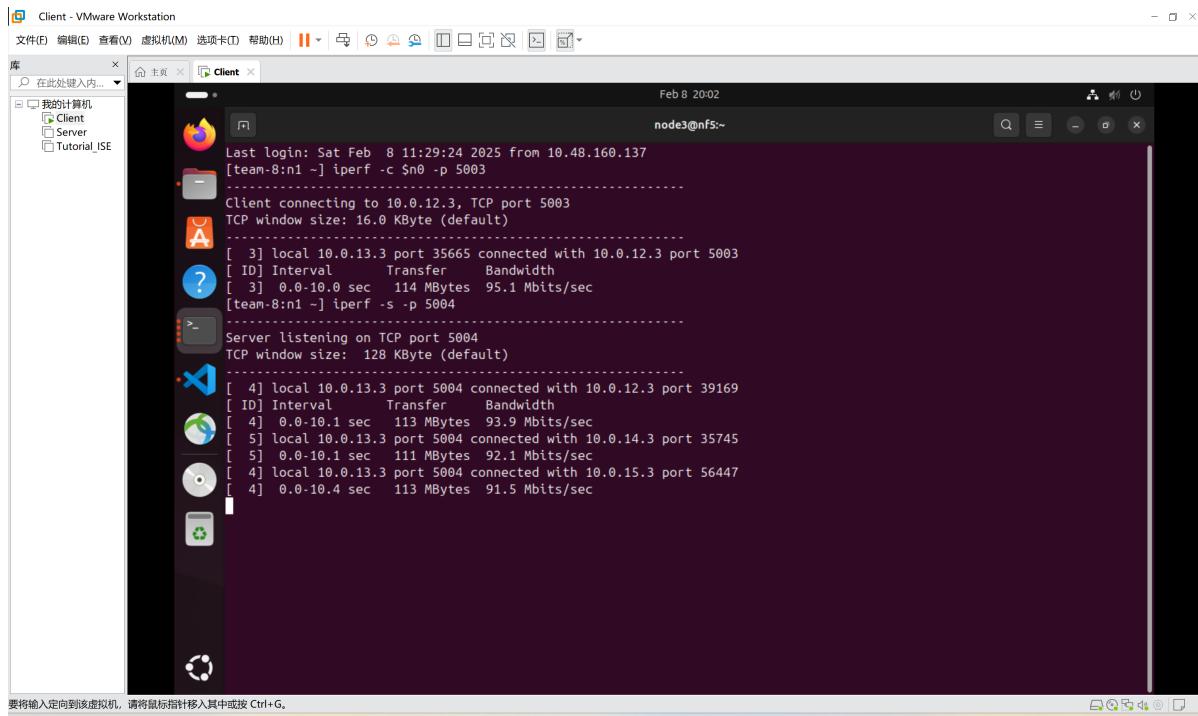
5.6 Test iperf with script

- n0 as TCP server

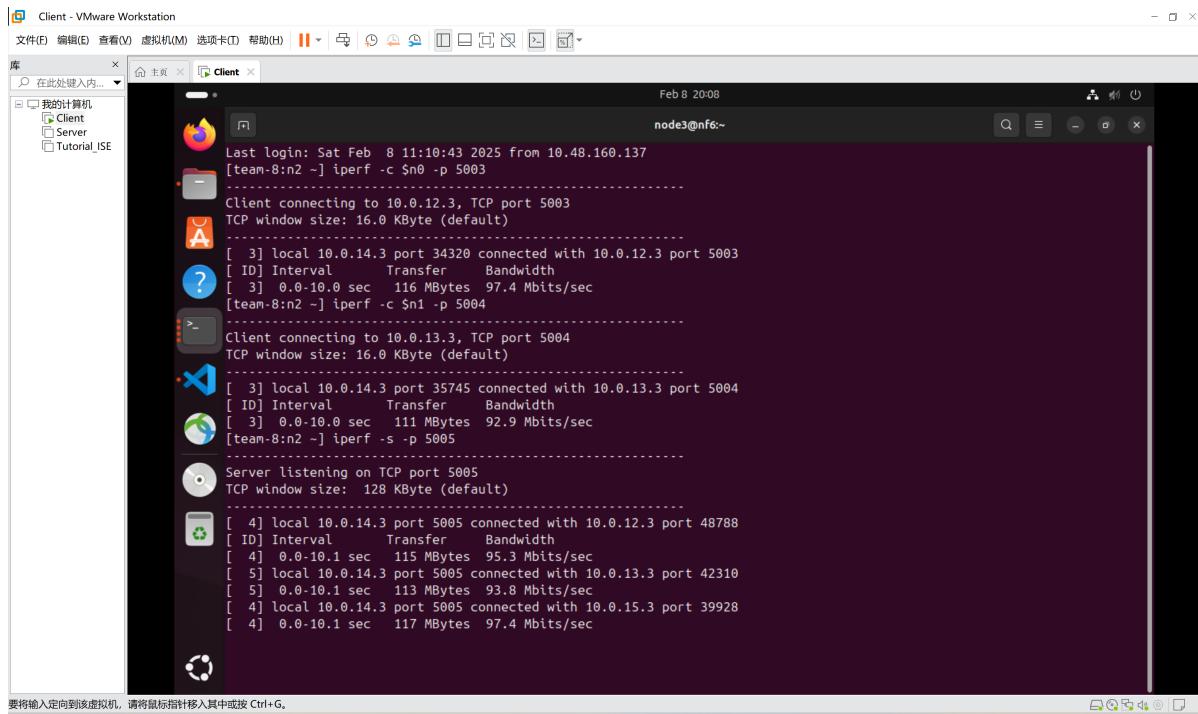
The screenshot shows a terminal window titled 'Client' running on a Linux system. The window title bar includes the application name 'Client - VMware Workstation' and the current date and time 'Feb 8 19:57'. The terminal window displays the output of an 'iperf' test. The output shows the following details:

```
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
```

- n1 as TCP server



- n2 as TCP server



- n3 as TCP server

Client - VMware Workstation

文件(E) 编辑(E) 查看(V) 虚拟机(M) 选项卡(T) 帮助(H) |

库 在此处键入内容...

我的计算机

- Client
- Server
- Tutorial.ISE

Client

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
```

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。

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

Client - VMware Workstation

文件(f) 编辑(E) 查看(V) 虚拟机(M) 选项卡(O) 帮助(H) || |

库

在此处键入内容...

我的计算机 Client

Feb 8 19:34

netfpga@nf8:~

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 ~] 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 ~]

6.2 Check PID and Kill

6.3 Re-Run the iperf with reference_router.bit and check Bandwidth

- n0 as TCP server

Client - VMware Workstation

```
[ 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 $n3 -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
```

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。

- n1 as TCP server

Client - VMware Workstation

```
[ 3] local 10.0.13.3 port 42310 connected with 10.0.14.3 port 5006
[ ID] Interval      Transfer     Bandwidth
[ 3] 0.0-10.0 sec  113 MBytes  94.7 Mbits/sec
[team-8:n1 -] iperf -c $n3 -p 5006
-----
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
-----
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
```

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 TCP server

```

Feb 8 20:20
node3@nf7:~>

[ 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 5006
-----
Client connecting to 10.0.12.3, TCP port 5006
TCP window size: 16.0 KByte (default)

[ 3] local 10.0.14.3 port 42502 connected with 10.0.12.3 port 5006
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 446 MBytes 374 Mbits/sec
[team-8:n2 -] iperf -c $n1 -p 5006
-----
Client connecting to 10.0.13.3, TCP port 5006
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 5001
-----
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

```

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 TCP server

```

Feb 8 20:22
node3@nf7:~>

[ 3] local 10.0.15.3 port 35179 connected with 10.0.12.3 port 5006
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 445 MBytes 373 Mbits/sec
[team-8:n3 -] iperf -c $n1 -p 5001
-----
Client connecting to 10.0.13.3, TCP port 5001
TCP window size: 16.0 KByte (default)

[ 3] local 10.0.15.3 port 42724 connected with 10.0.13.3 port 5001
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 417 MBytes 349 Mbits/sec
[team-8:n3 -] iperf -c $n2 -p 5001
-----
Client connecting to 10.0.14.3, TCP port 5002
TCP window size: 16.0 KByte (default)

[ 3] local 10.0.15.3 port 60644 connected with 10.0.14.3 port 5002
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 423 MBytes 355 Mbits/sec
[team-8:n3 -] iperf -s -p 5003
-----
Server listening on TCP port 5003
TCP window size: 128 KByte (default)

[ 4] local 10.0.15.3 port 5003 connected with 10.0.12.3 port 56644
[ 5] local 10.0.15.3 port 5003 connected with 10.0.13.3 port 47950
[ ID] Interval Transfer Bandwidth
[ 4] 0.0-10.5 sec 402 MBytes 320 Mbits/sec
[ 5] 0.0-10.0 sec 445 MBytes 373 Mbits/sec
[ 6] local 10.0.15.3 port 5003 connected with 10.0.14.3 port 60360
[ 6] 0.0-10.1 sec 431 MBytes 359 Mbits/sec

```

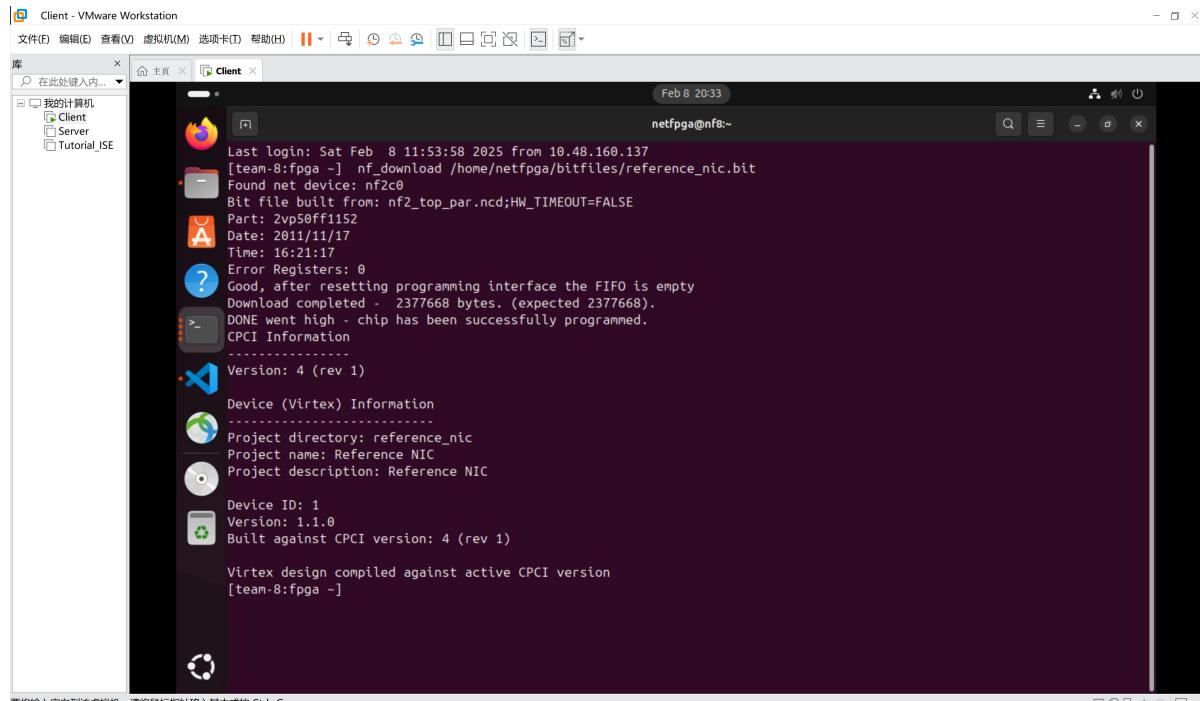
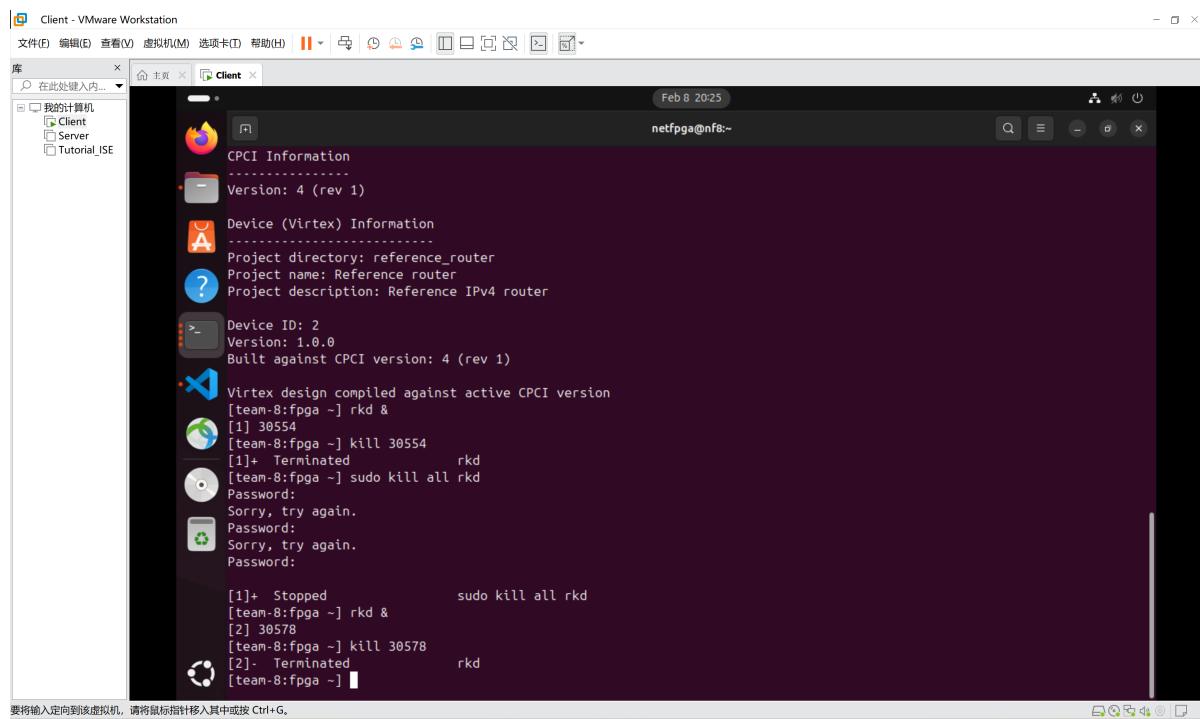
要将输入定向到该虚拟机，请将鼠标指针移入其中或按 Ctrl+G。

Server	Client	Protocol	Bandwidth (Mbits/sec)
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

Server	Client	Protocol	Bandwidth (Mbits/sec)
n2	n1	TCP	439
n2	n3	TCP	354
n3	n0	TCP	320
n3	n1	TCP	373
n3	n2	TCP	359

6.4 Re-Run the iperf with reference_nic.bit and check Bandwidth

- Kill rkd & download reference_nic.bit



- n0 as UDP server

The screenshot shows a VMware Workstation client window titled "Client - VMware Workstation". The terminal window displays the following output:

```
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 56838
[ 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

The screenshot shows a VMware Workstation client window titled "Client - VMware Workstation". The terminal window displays the following output:

```
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 Jitter Lost/Total Datagrams
[ 3] 0.0-10.0 sec 1.25 MBBytes 1.05 Mbits/sec
[ 3] Sent 893 datagrams
[ 3] Server Report:
[ 3] 0.0-10.0 sec 1.25 MBBytes 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@nf7:~-
[ 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
n1	n0	UDP	1.05
n1	n2	UDP	1.05
n1	n3	UDP	1.05
n2	n0	UDP	1.05

Server	Client	Protocol	Bandwidth (Mbits/sec)
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

4. GitHub Link

- This Lab's update and commit history could be checked by the below link:
 - https://github.com/yuezhenglingluan/USC_EE533_lab4.git