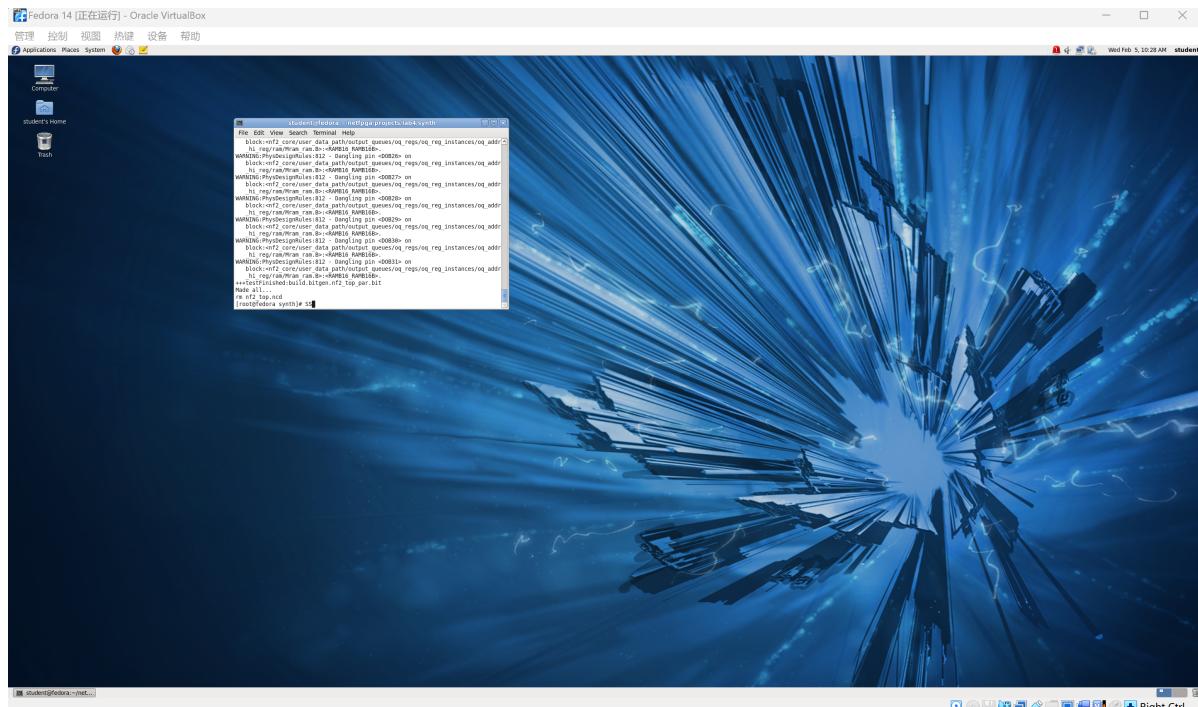


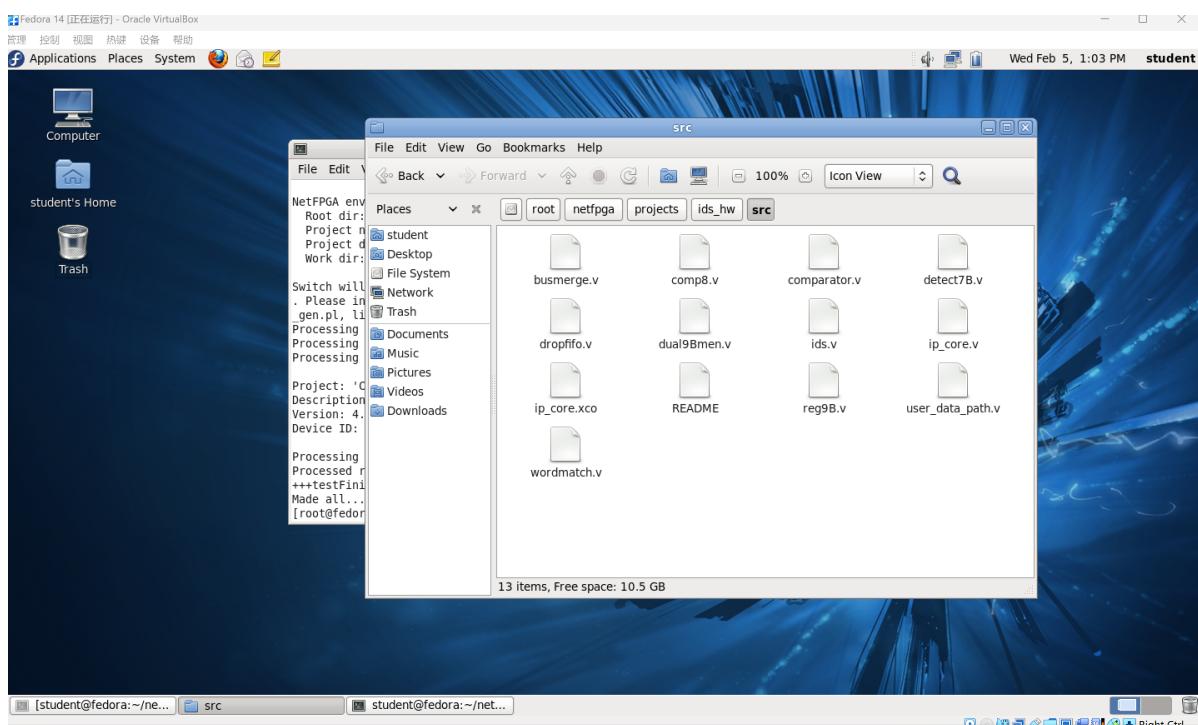
EE533_Lab4_Report

1. Download and Setup Fedora VM

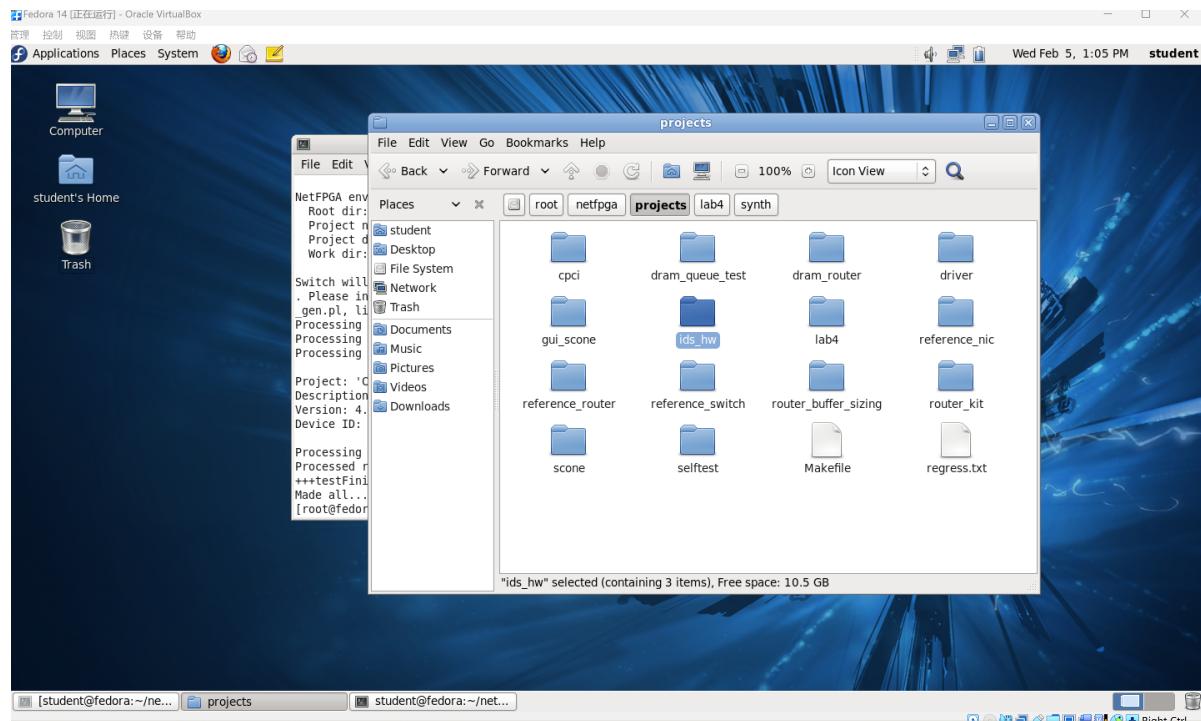


2. Compile and generate a design bitfile for NetFPGA

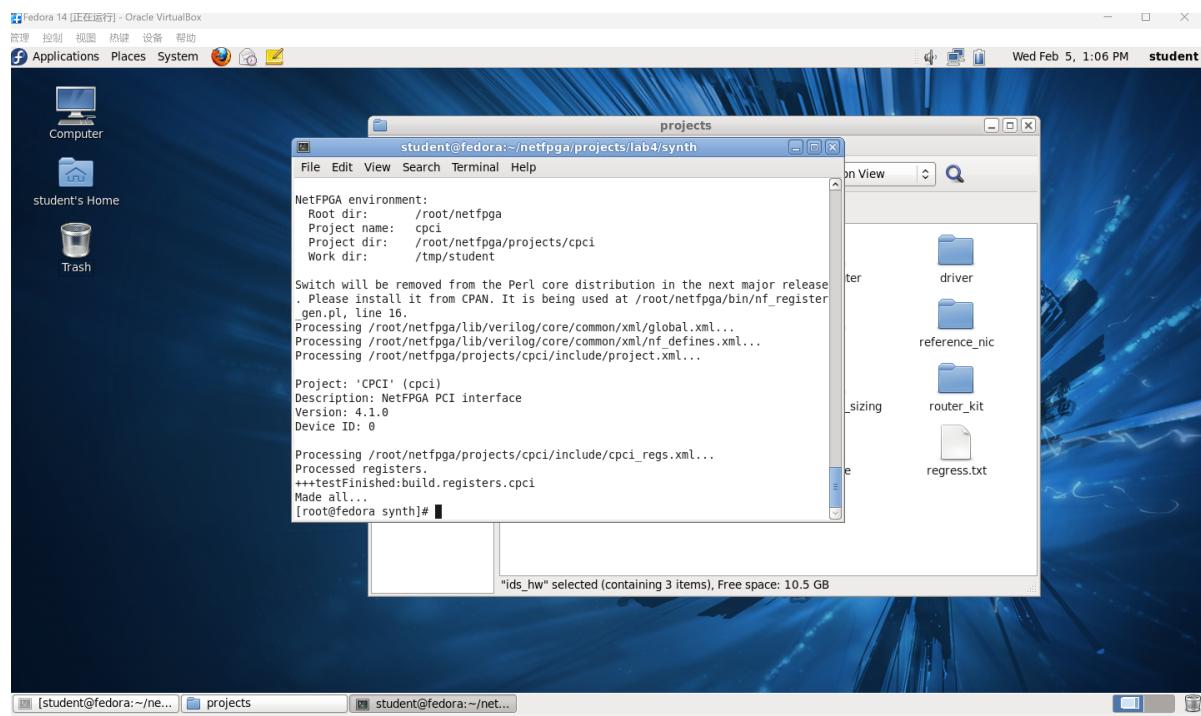
2.1 Extract ids_hw and copy all Verilog and ip core files into ids_hw/src



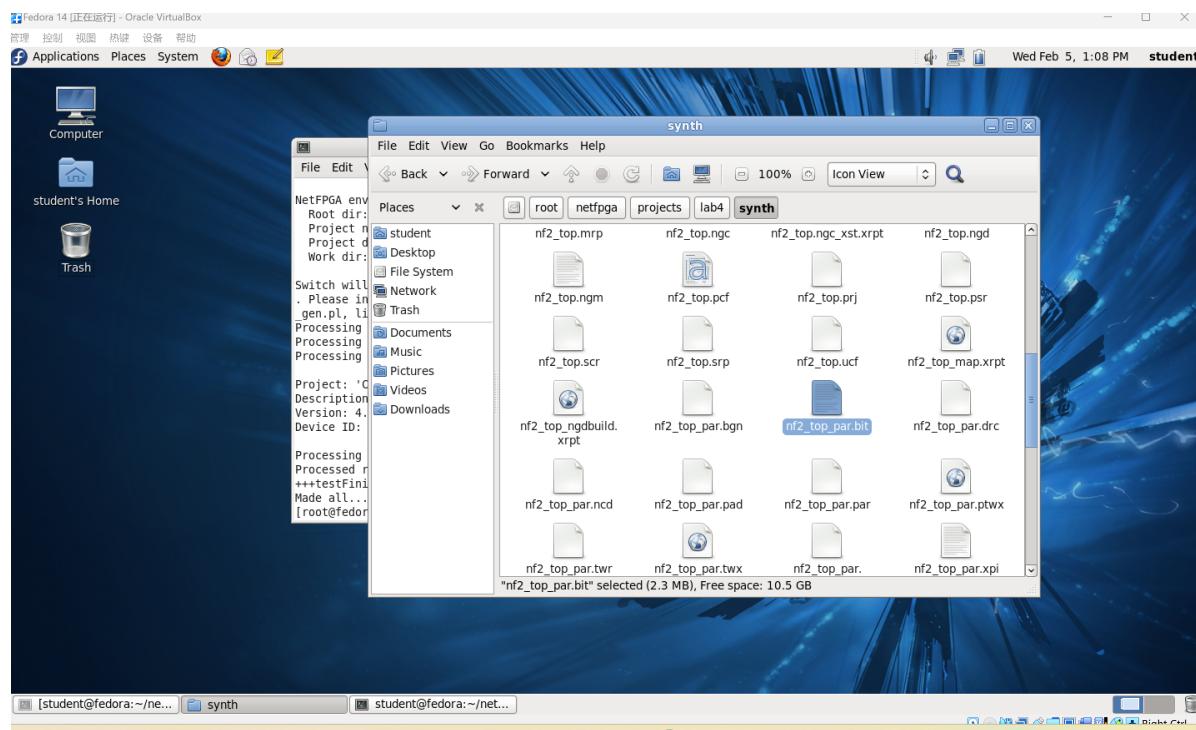
2.2 Copy all of source files within ids_hw into corresponding folders into NetFPGA project folder



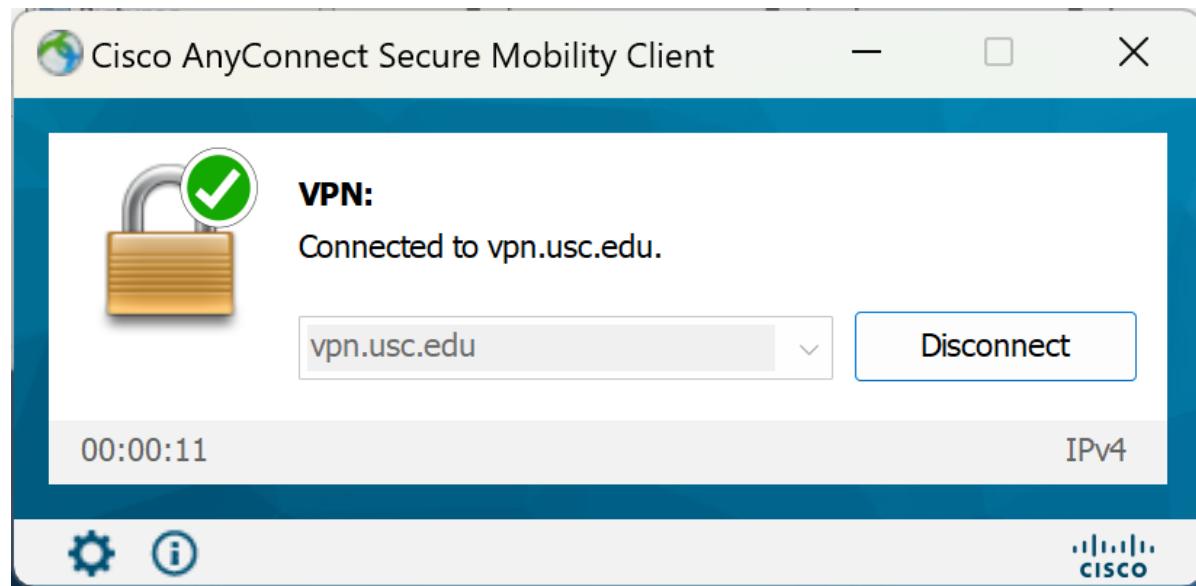
2.3 Compile the design by 'cd' into the synth folder type 'make'



2.4 '*.bit' file generated

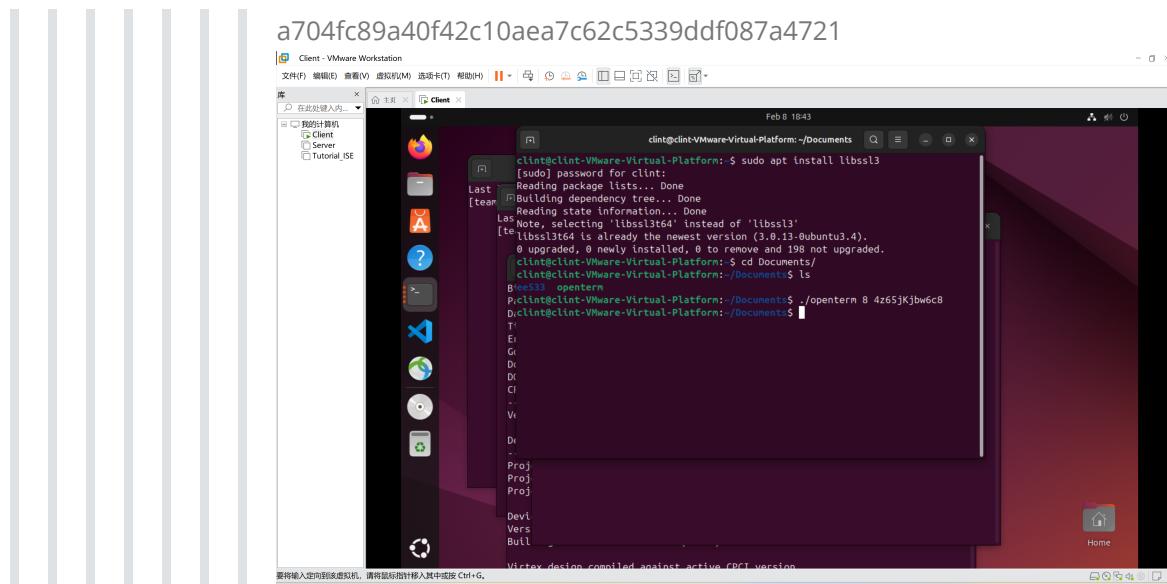


3. Set Up VPN to USC



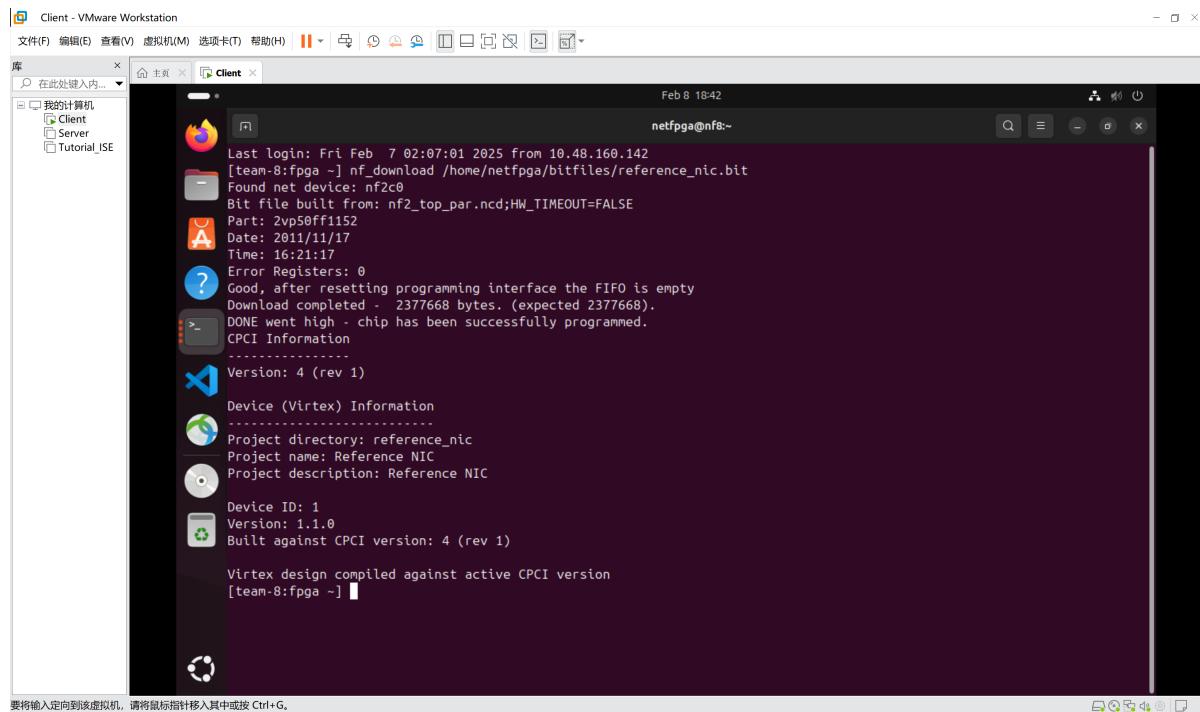
4. NetFPGA Environment

<<<<< HEAD

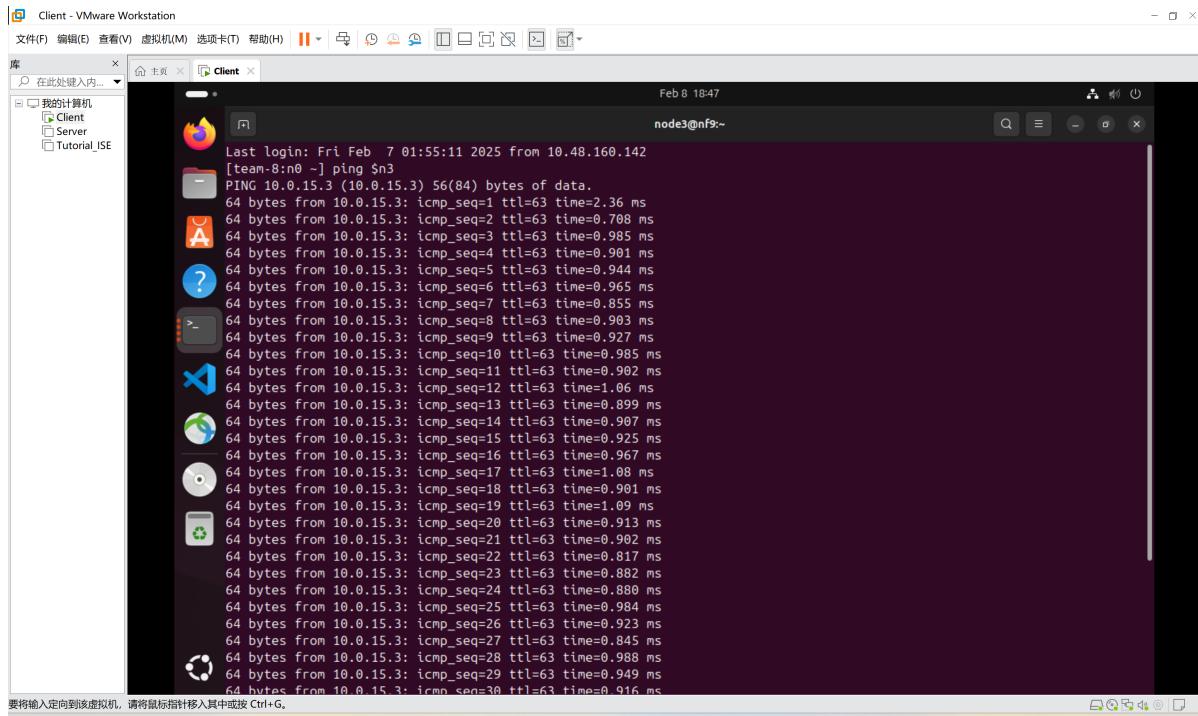


5. NetFPGA-based Linux Kernel IP Router

5.1 Test NetFPGA as network interface card



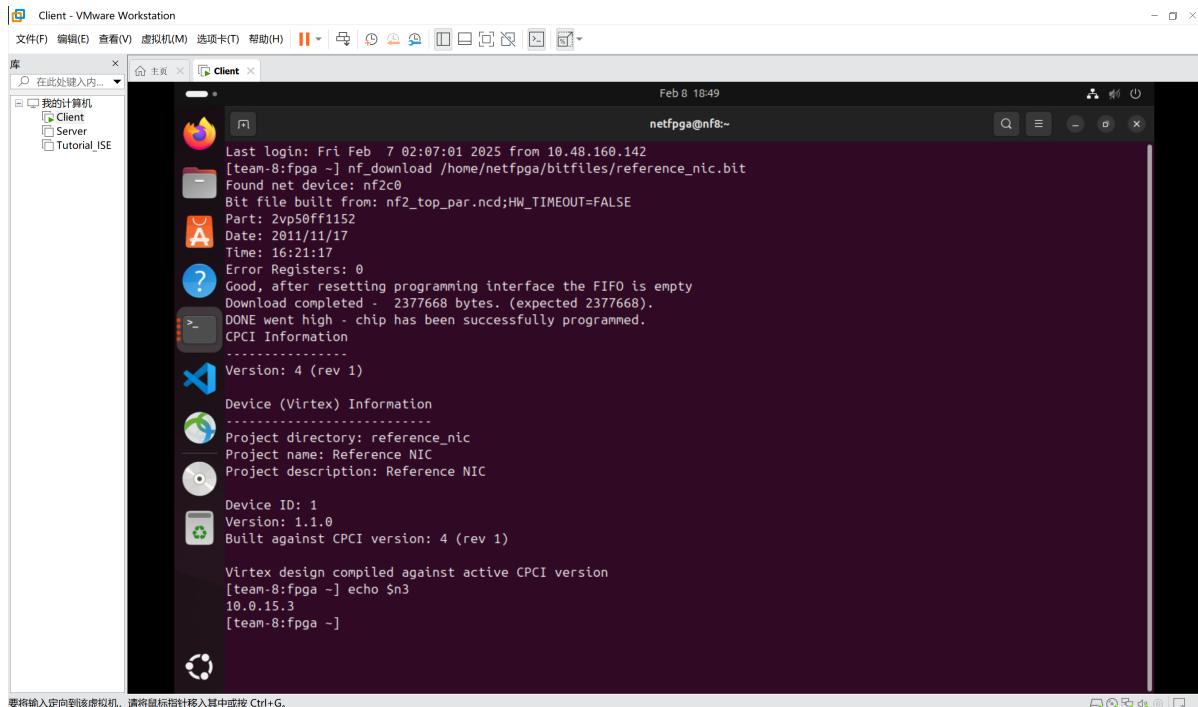
5.2 Test ping from n0 to n3



```
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

```
Feb 8 18:50
node3@nf9:~>

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

```
Feb 8 18:53
node3@nf9:~>

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

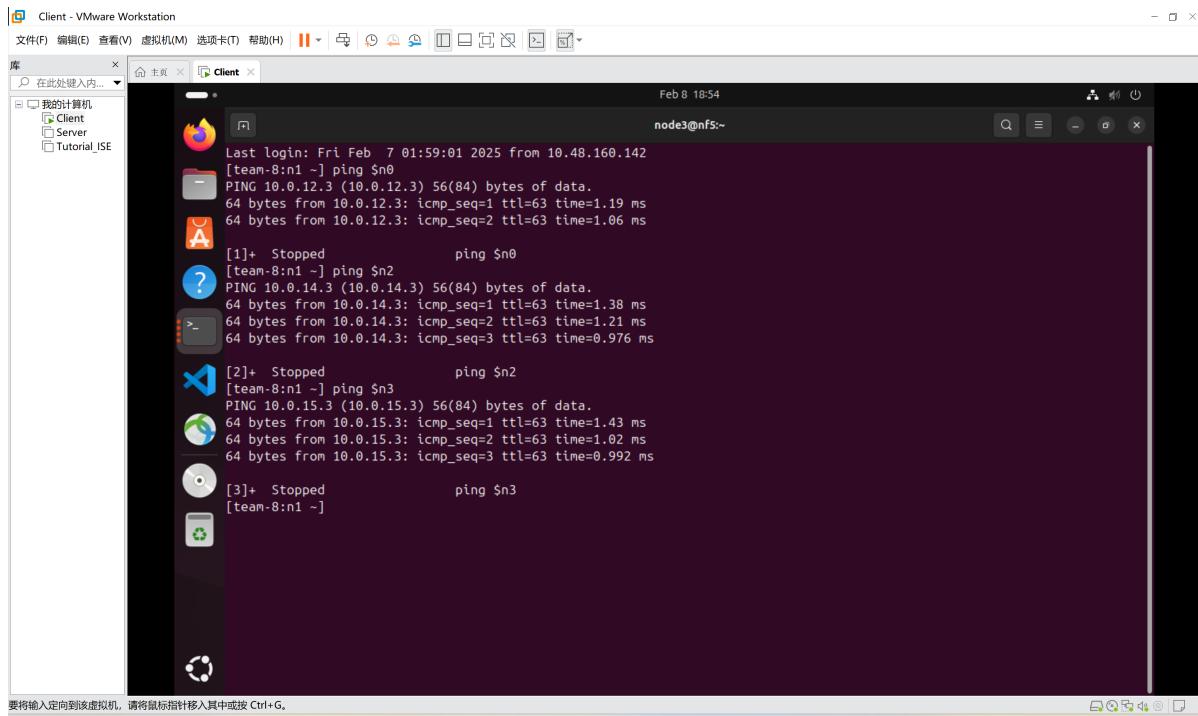
[3]+ Stopped ping $n1
[team-8:n0 ~] ping $n2
PING 10.0.14.3 (10.0.14.3) 56(84) bytes of data.
64 bytes from 10.0.14.3: icmp_seq=1 ttl=63 time=2.16 ms
64 bytes from 10.0.14.3: icmp_seq=2 ttl=63 time=1.07 ms

[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



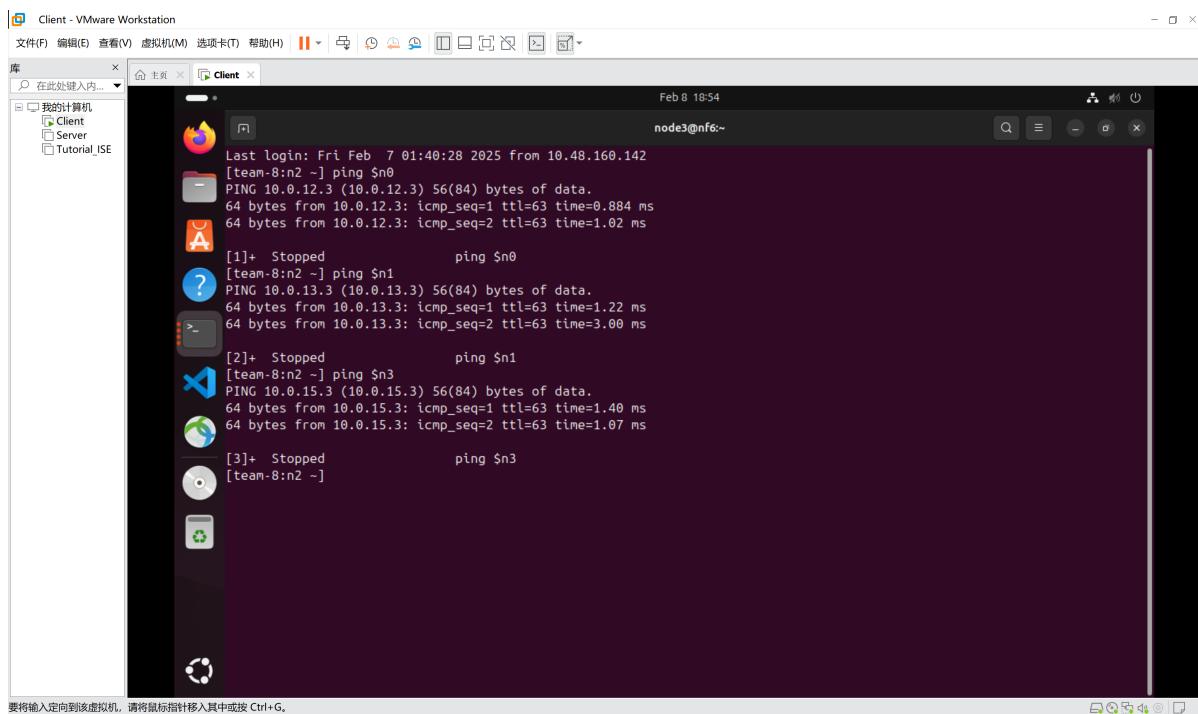
```
Last login: Fri Feb 7 01:59:01 2025 from 10.48.160.142
[team-8:n1 ~] ping $n0
PING 10.0.12.3 (10.0.12.3) 56(84) bytes of data.
64 bytes from 10.0.12.3: icmp_seq=1 ttl=63 time=1.19 ms
64 bytes from 10.0.12.3: icmp_seq=2 ttl=63 time=1.06 ms

[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
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



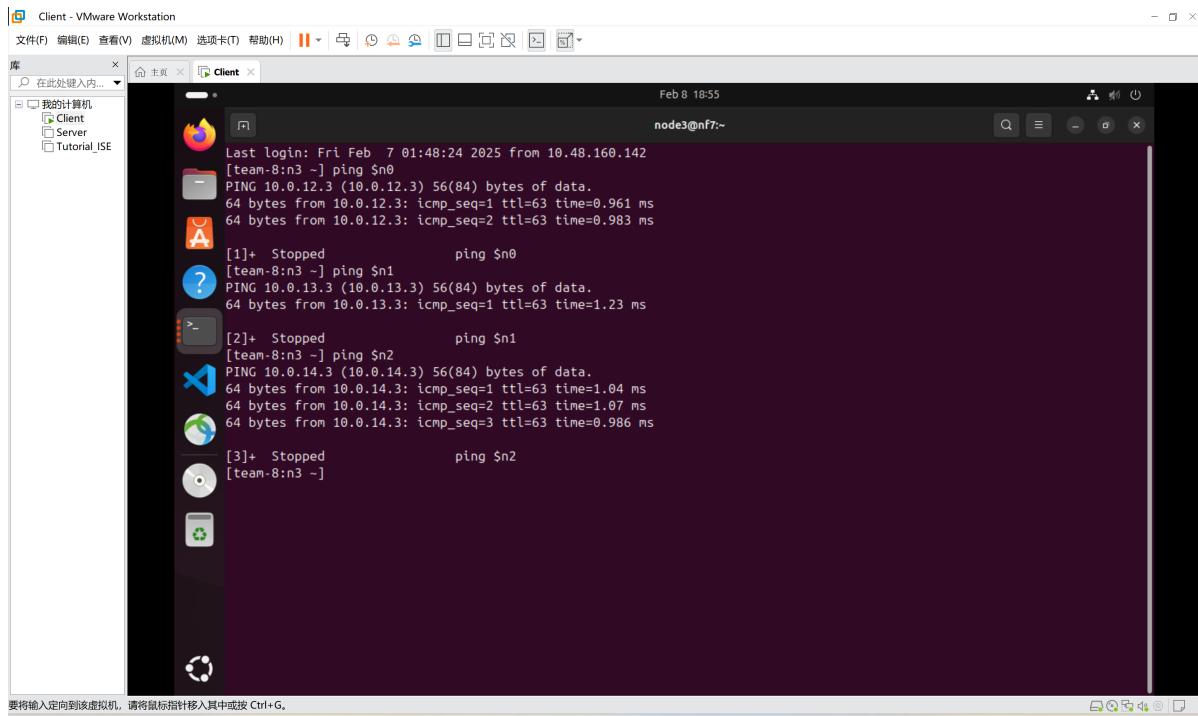
```
Last login: Fri Feb 7 01:40:28 2025 from 10.48.160.142
[team-8:n2 ~] ping $n0
PING 10.0.12.3 (10.0.12.3) 56(84) bytes of data.
64 bytes from 10.0.12.3: icmp_seq=1 ttl=63 time=0.884 ms
64 bytes from 10.0.12.3: icmp_seq=2 ttl=63 time=1.02 ms

[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



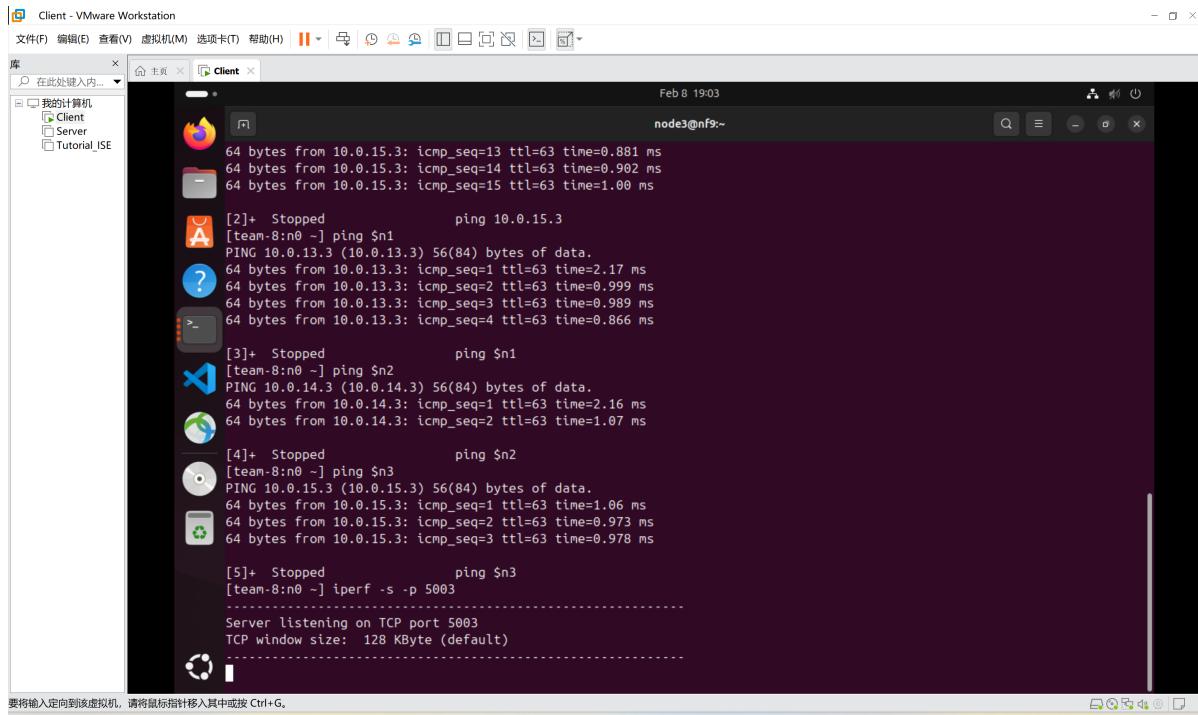
The screenshot shows a terminal window titled "Client - VMware Workstation". The terminal is running on node3 (IP 10.0.15.3). It displays three separate ping commands:

- [team-8:n3 ~] ping \$n0
- [team-8:n3 ~] ping \$n1
- [team-8:n3 ~] ping \$n2

Each ping command shows multiple ICMP echo requests sent to the target IP (10.0.12.3, 10.0.13.3, or 10.0.14.3) with TTL=63 and various round-trip times (e.g., 0.961 ms, 1.23 ms, etc.).

5.5 Test with iperf

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



The screenshot shows a terminal window titled "Client - VMware Workstation". The terminal is running on node3 (IP 10.0.15.3). It shows the following sequence of commands:

- [team-8:n3 ~] ping 10.0.15.3
- [team-8:n0 ~] ping \$n1
- [team-8:n0 ~] ping \$n2
- [team-8:n0 ~] ping \$n3
- [team-8:n0 ~] iperf -s -p 5003

The final command, iperf -s -p 5003, indicates that node3 is now configured as a TCP server listening on port 5003.

- 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 titled "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 window has a dark theme and includes a vertical dock on the left side.

```
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 |

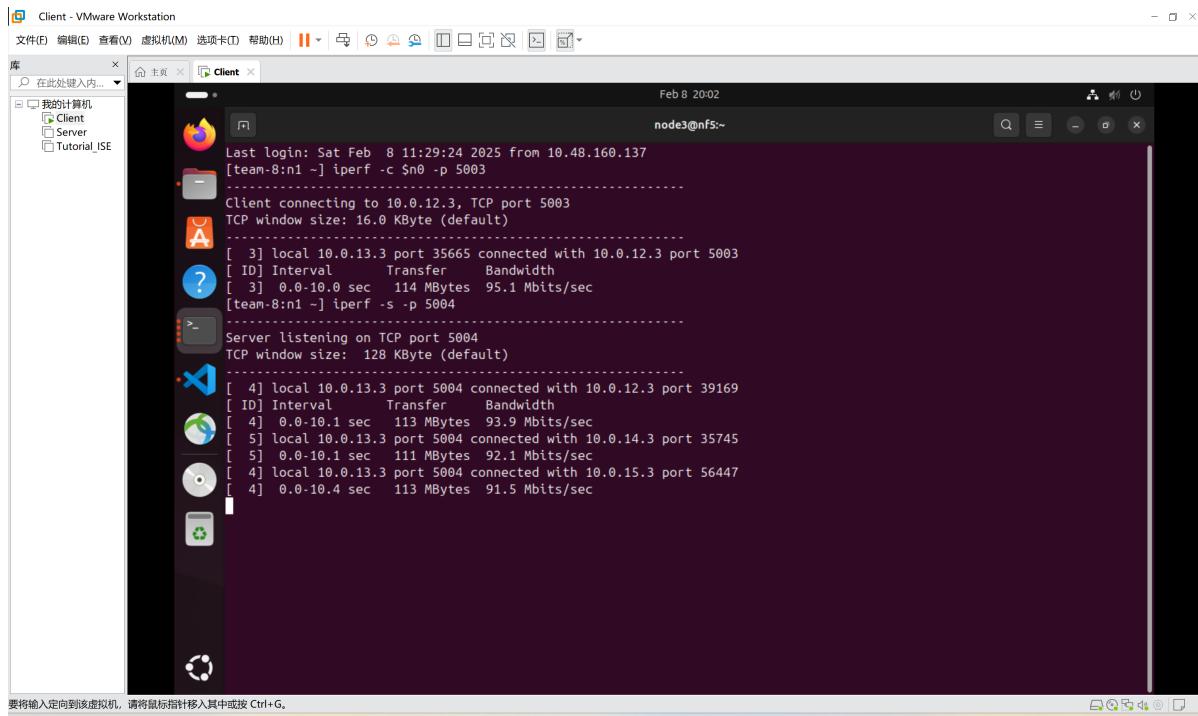
5.6 Test iperf with script

- n0 as TCP server

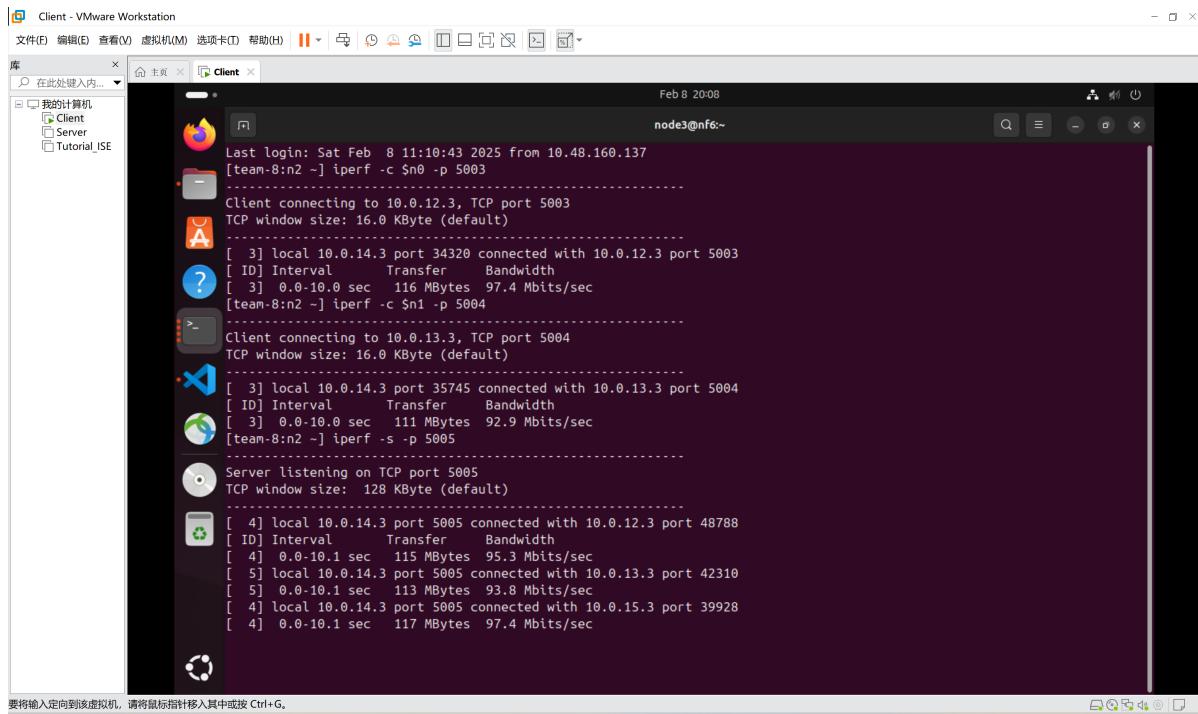
The screenshot shows a terminal window titled 'Client' running on a Linux system. The window title bar includes the application name 'Client - VMware Workstation' and the current date and time 'Feb 8 19:57'. The terminal window displays the output of an 'iperf' test. The output shows the following details:

```
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

The screenshot shows a terminal window titled 'Client' running on a Linux desktop environment. The terminal output details a series of TCP performance tests (iperf) conducted between various hosts:

- Test 1: Client connects to 10.0.13.3 (port 5004).
 - Bandwidth: 90.7 Mbytes/sec
 - TCP window size: 16.0 KByte (default)
- Test 2: Client connects to 10.0.14.3 (port 5005).
 - Bandwidth: 94.5 Mbytes/sec
 - TCP window size: 16.0 KByte (default)
- Test 3: Client connects to 10.0.15.3 (port 5005).
 - Bandwidth: 98.2 Mbytes/sec
 - TCP window size: 128 KByte (default)
- Test 4: Server listening on port 5006.
 - Bandwidth: 93.3 Mbytes/sec
 - TCP window size: 128 KByte (default)
- Test 5: Client connects to 10.0.12.3 (port 33248).
 - Bandwidth: 90.3 Mbytes/sec
 - TCP window size: 128 KByte (default)
- Test 6: Client connects to 10.0.13.3 (port 41299).
 - Bandwidth: 93.3 Mbytes/sec
 - TCP window size: 128 KByte (default)
- Test 7: Client connects to 10.0.14.3 (port 58261).
 - Bandwidth: 95.5 Mbytes/sec
 - TCP window size: 128 KByte (default)

The terminal interface includes a sidebar with icons for '我的计算机' (My Computer), 'Client', 'Server', and 'Tutorial_ISE'. The status bar at the bottom indicates: '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。' (Please move the mouse pointer to the virtual machine or press Ctrl+G to direct input.)

| 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
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 ~] 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 ~]
```

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。

6.2 Check PID and Kill

```
Client - VMware Workstation
Feb 8 20:12
netfpga@nf8:~$ Version: 1.1.0
Built against 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

- n1 as TCP server

```
[ 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-8:1 ~] iperf -c $n3 -p 5006
-----
[ 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-8:1 ~] iperf -c $n0 -p 5006
-----
[ 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-8:1 ~] iperf -s -p 5001
-----
Server listening on TCP port 5001
[ 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

Client - VMware Workstation

文件(E) 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 Server Tutorial.ISE

Feb 8 20:20 node3@nf6:~

```
[ 3] local 10.0.14.3 port 42502 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
-----
[A] 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
-----
[V] Client connecting to 10.0.13.3, TCP port 5001
TCP window size: 18.3 KByte (default)
[ 3] local 10.0.14.3 port 49500 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

Client - VMware Workstation

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

库 在此处键入内容...

我的计算机

- Client
- Server
- Tutorial.ISE

Client

Feb 8 20:22

node3@nf7:~

```
[ 3] local 10.0.15.3 port 35179 connected with 10.0.12.3 port 5000
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 445 MBytes 373 Mbits/sec
[team-8:n3 ~] iperf -c $n1 -p 5001
-----
[A] 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 5002
-----
[V] Client connecting to 10.0.14.3, TCP port 5002
TCP window size: 16.0 KByte (default)
[ 3] local 10.0.15.3 port 609644 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
```

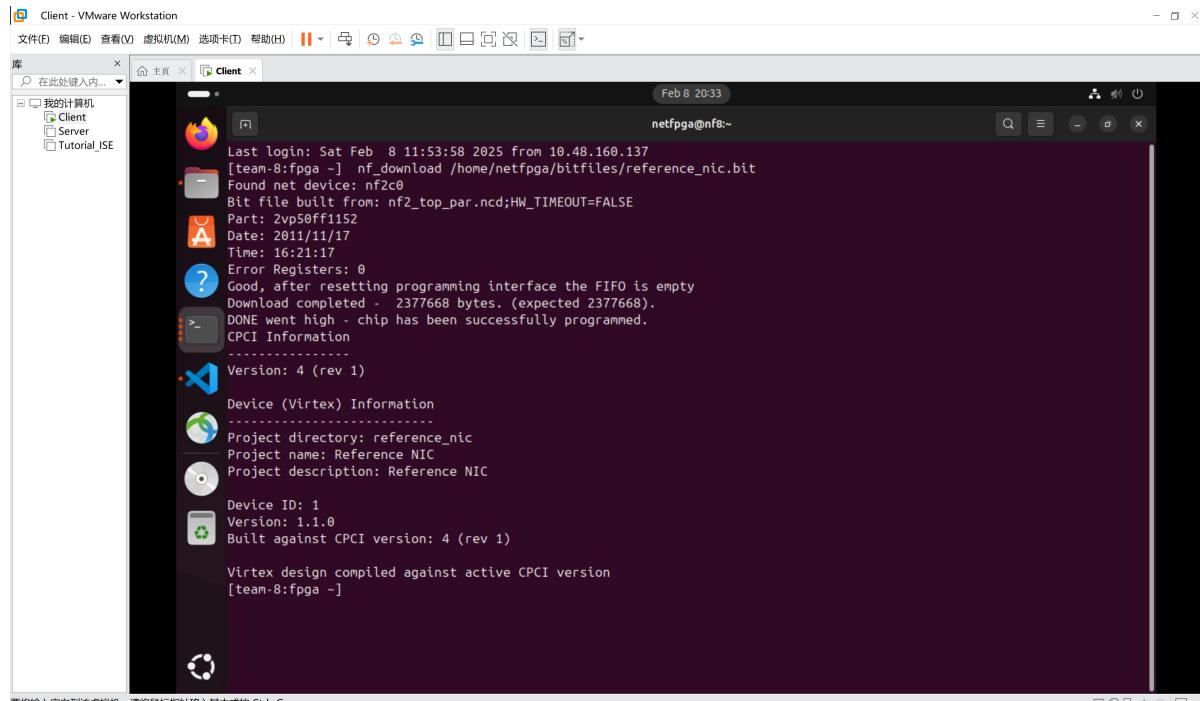
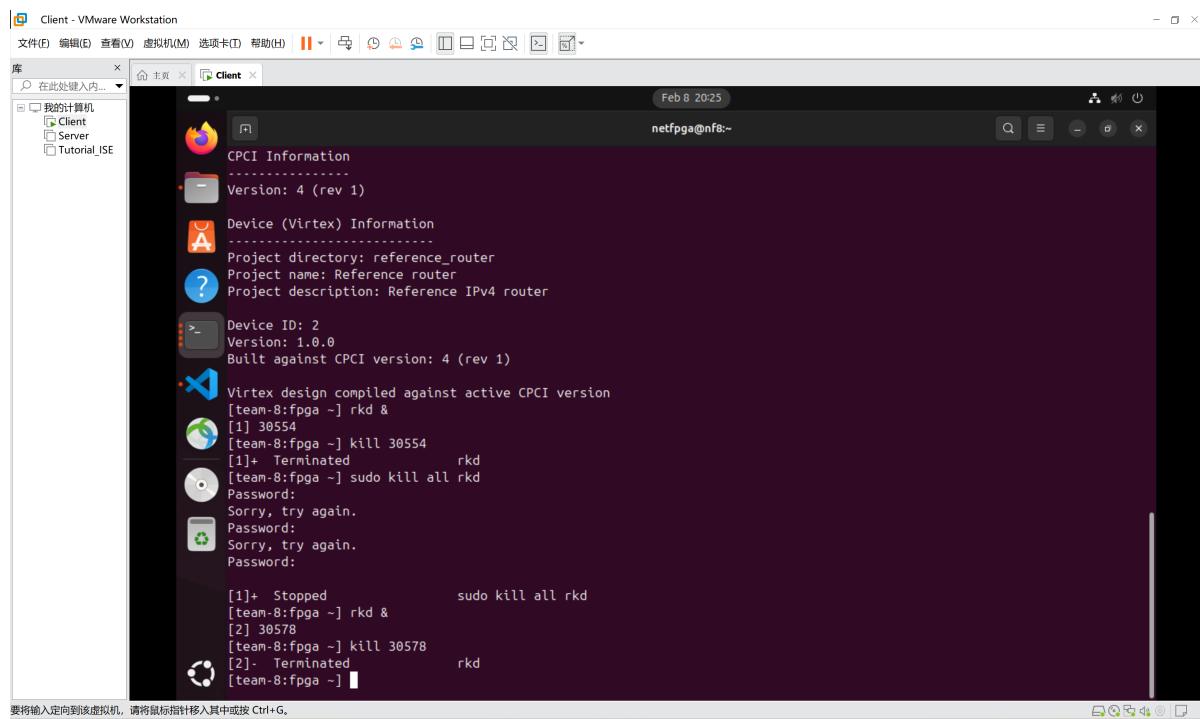
要将输入定向到该虚拟机，请将鼠标指针移入其中或按 Ctrl+G。

| 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 |

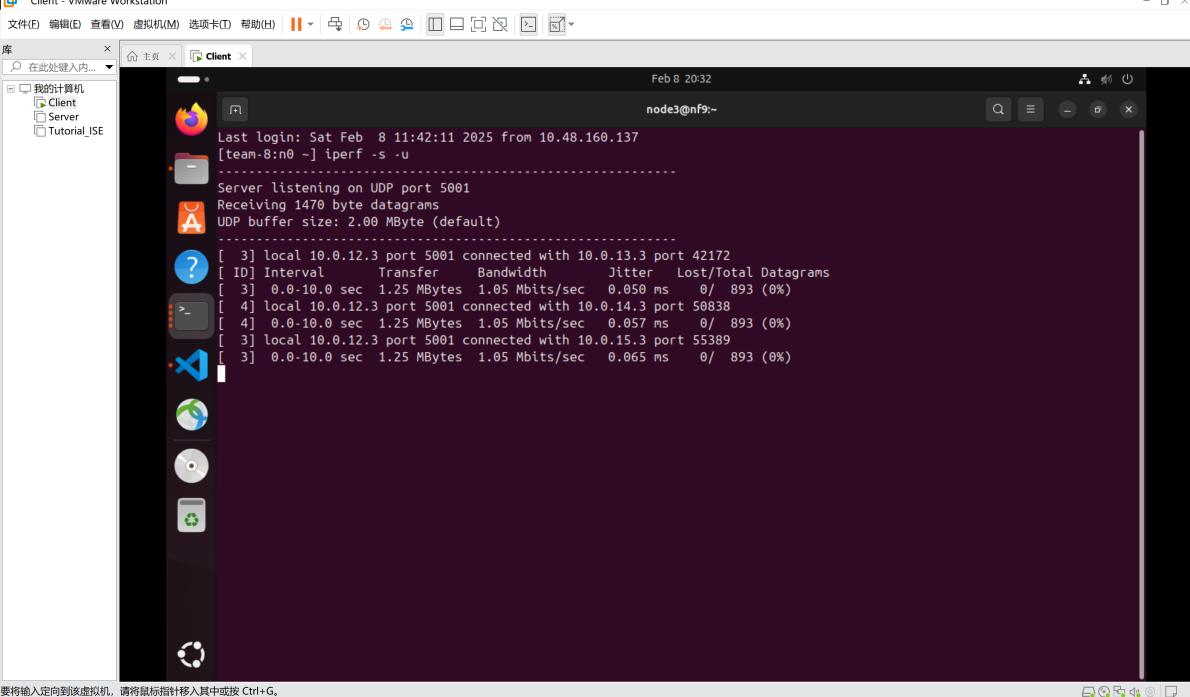
| Server | Client | Protocol | Bandwidth (Mbits/sec) |
|---------------|---------------|-----------------|------------------------------|
| n2 | n1 | TCP | 439 |
| n2 | n3 | TCP | 354 |
| n3 | n0 | TCP | 320 |
| n3 | n1 | TCP | 373 |
| n3 | n2 | TCP | 359 |

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

- Kill rkd & download reference_nic.bit



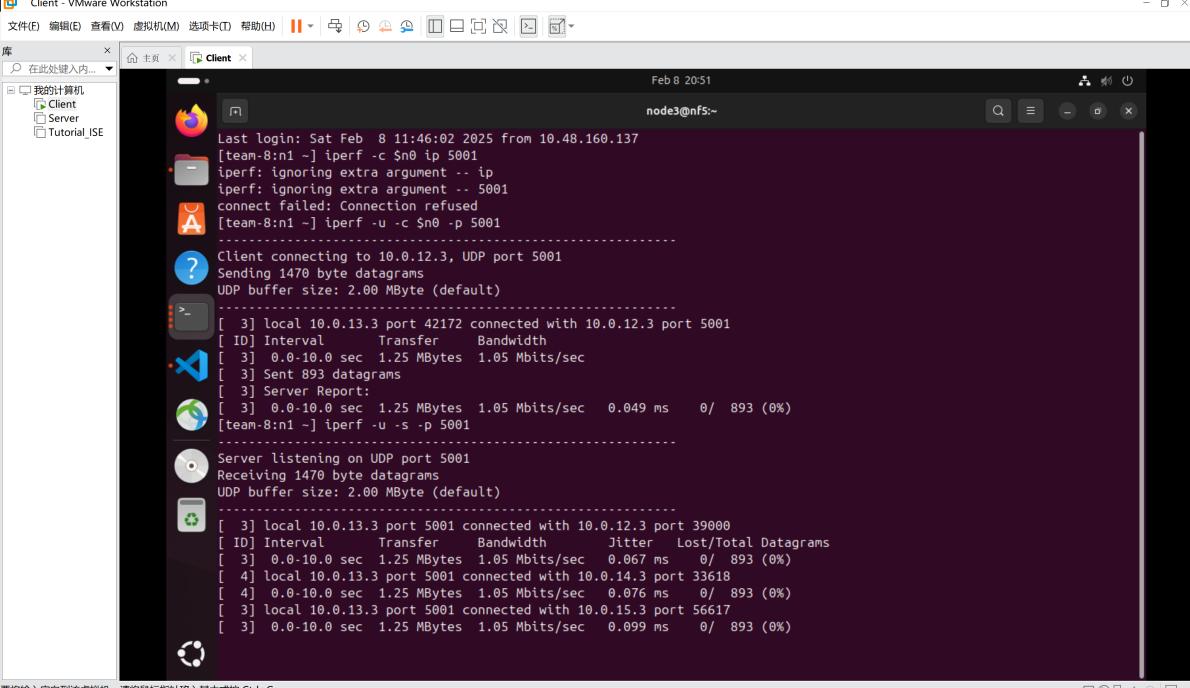
- n0 as UDP server



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 MBBytes 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 MBBytes 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 MBBytes 1.05 Mbits/sec 0.099 ms 0/ 893 (0%)
```

- n2 as UDP 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

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

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

Feb 8 20:55

node3@n7:-~

```
[ 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)

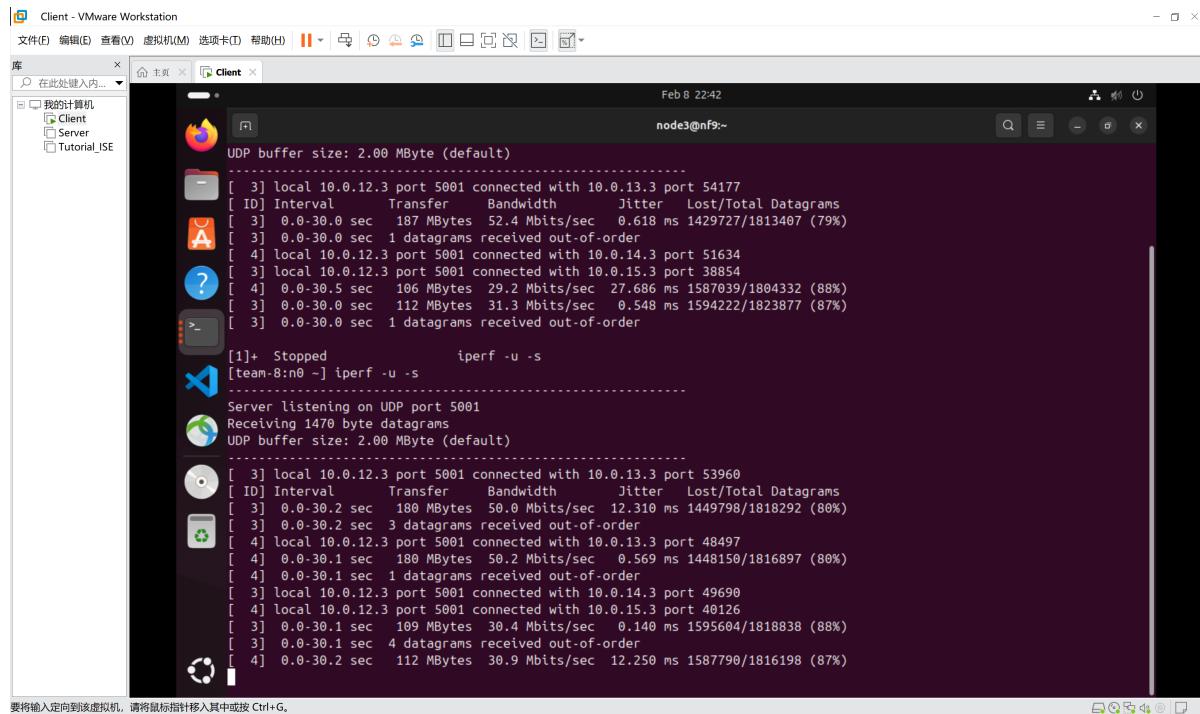
[ 3] local 10.0.15.3 port 5003 connected with 10.0.12.3 port 42521
[ ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[ 3] 0.0-10.0 sec 1.25 MBYTES 1.05 Mbits/sec 0.104 ms 0/ 893 (0%)
[ 4] local 10.0.15.3 port 5003 connected with 10.0.13.3 port 36704
[ 4] 0.0-10.0 sec 1.25 MBYTES 1.05 Mbits/sec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

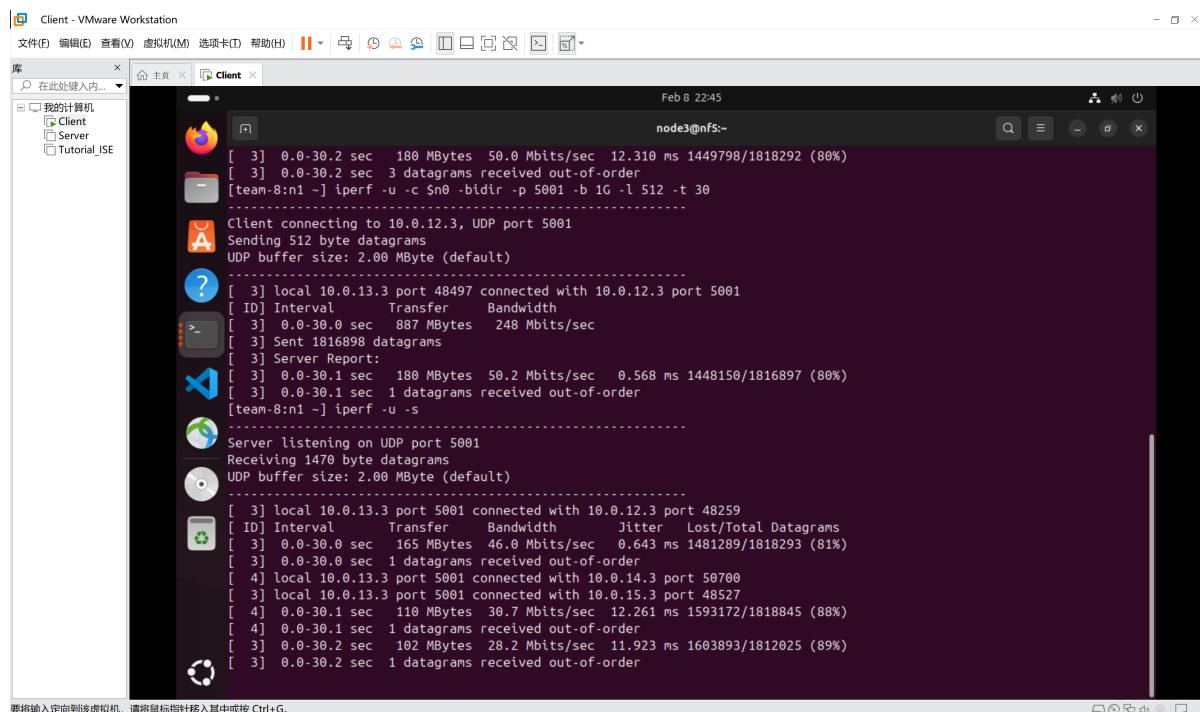
| Server | Client | Protocol | Bandwidth (Mbits/sec) |
|---------------|---------------|-----------------|------------------------------|
| n2 | n1 | UDP | 1.05 |
| n2 | n3 | UDP | 1.05 |
| n3 | n0 | UDP | 1.05 |
| n3 | n1 | UDP | 1.05 |
| n3 | n2 | UDP | 1.05 |

6.5 Testing bidir UDP on each node

- n0 as UDP server



- n1 as UDP server



- n2 as UDP server

```

Client - VMware Workstation
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
[ 1D] 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
[ 1D] 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%)
[team-8:n2 ~]

```

- n3 as UDP server

```

Client - VMware Workstation
Feb 8 22:49
node3@nf7:~>

[team-8: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
-----
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
[ 1D] 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%)
[team-8: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
[ 1D] 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 datagram received out-of-order
[ 5] 0.0-30.3 sec 146 MBytes 40.4 Mbits/sec 11.107 ms 1512261/1810614 (84%)
[team-8:n3 ~]

```

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