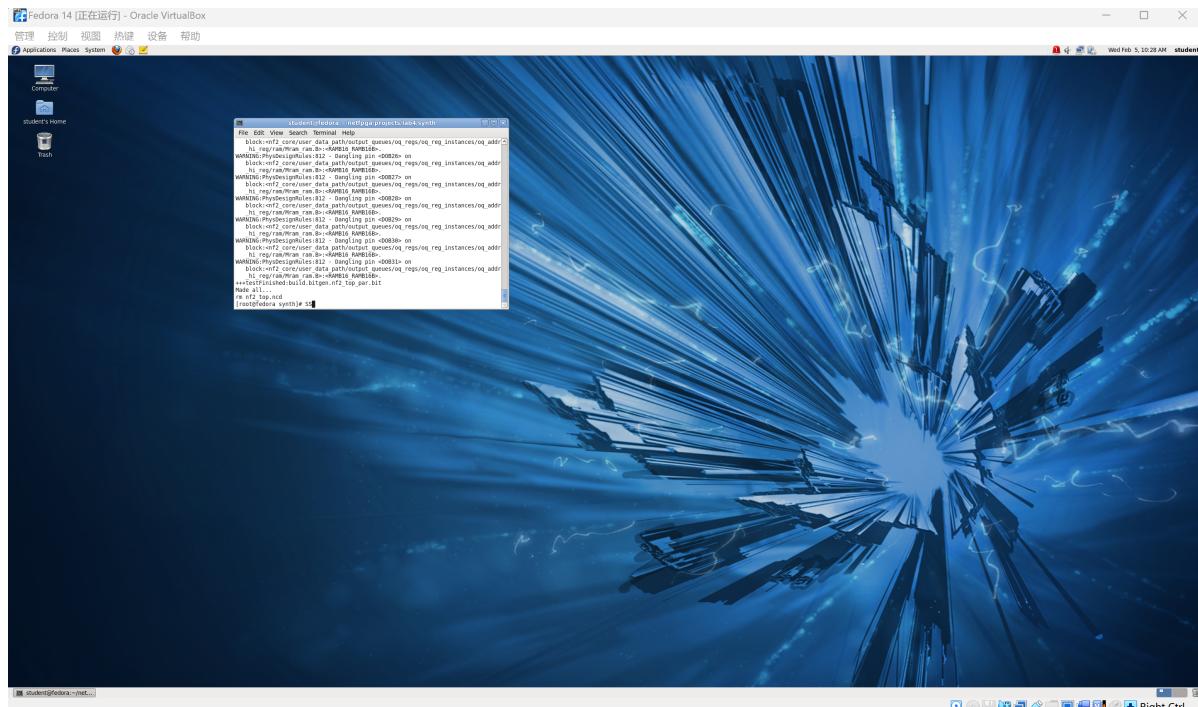


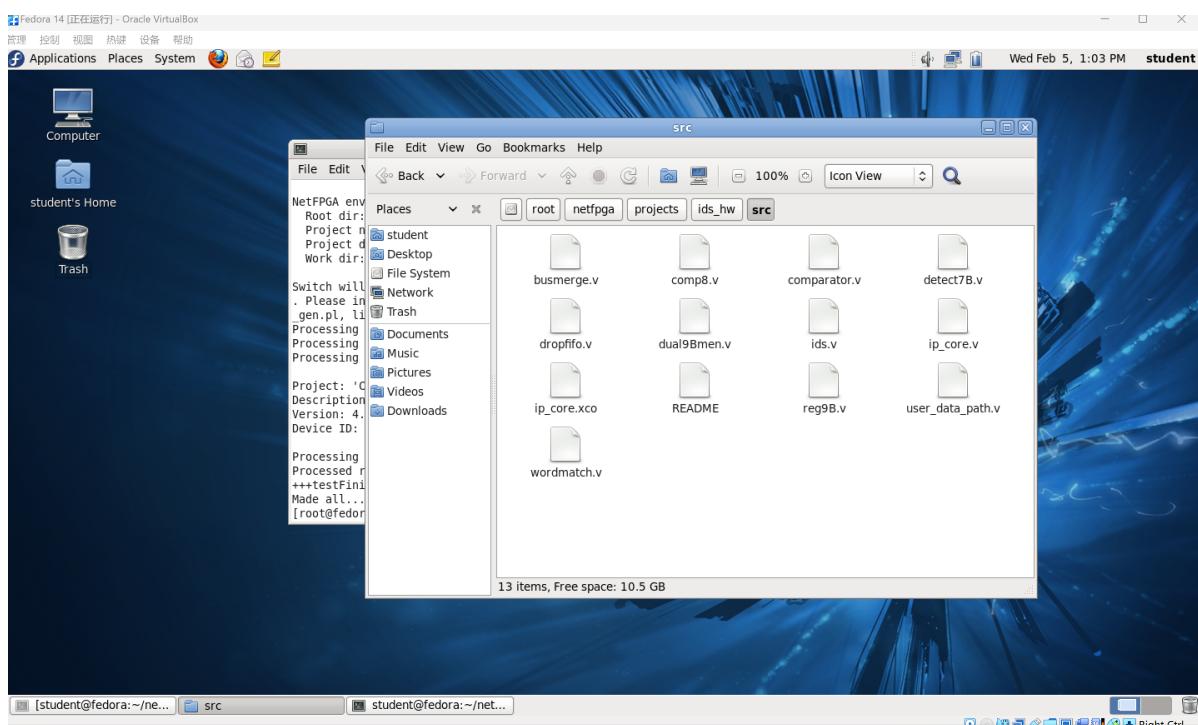
EE533_Lab4_Report

1. Download and Setup Fedora VM

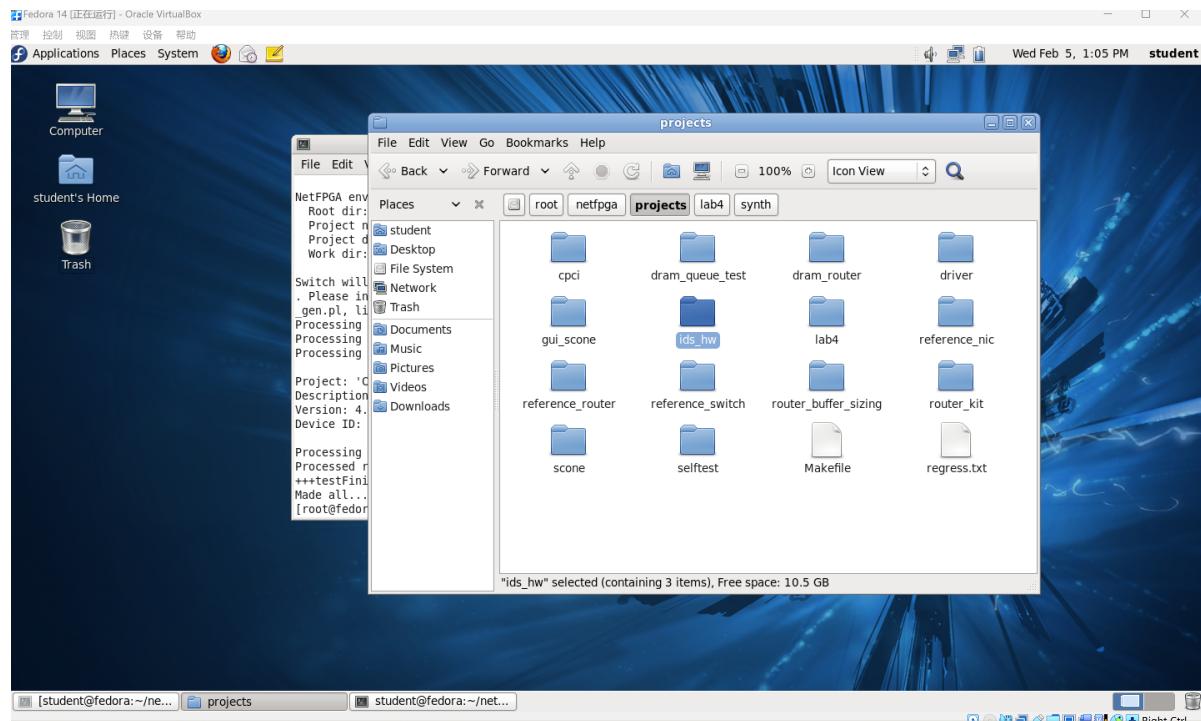


2. Compile and generate a design bitfile for NetFPGA

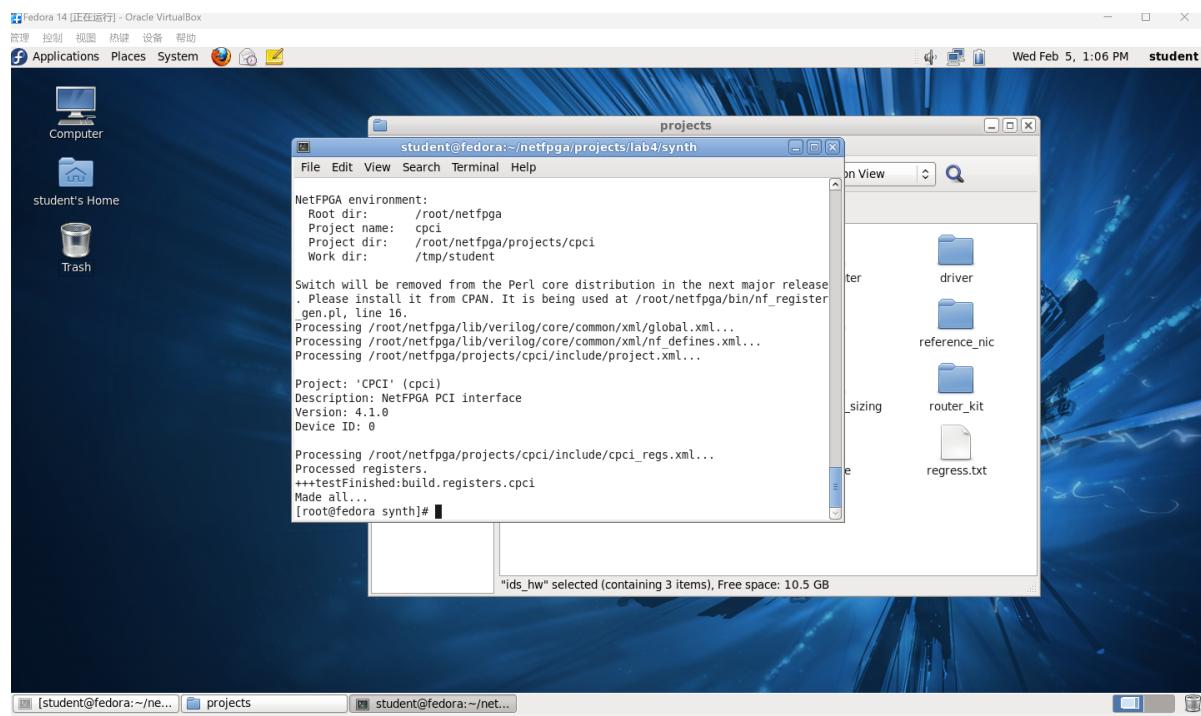
2.1 Extract ids_hw and copy all Verilog and ip core files into ids_hw/src



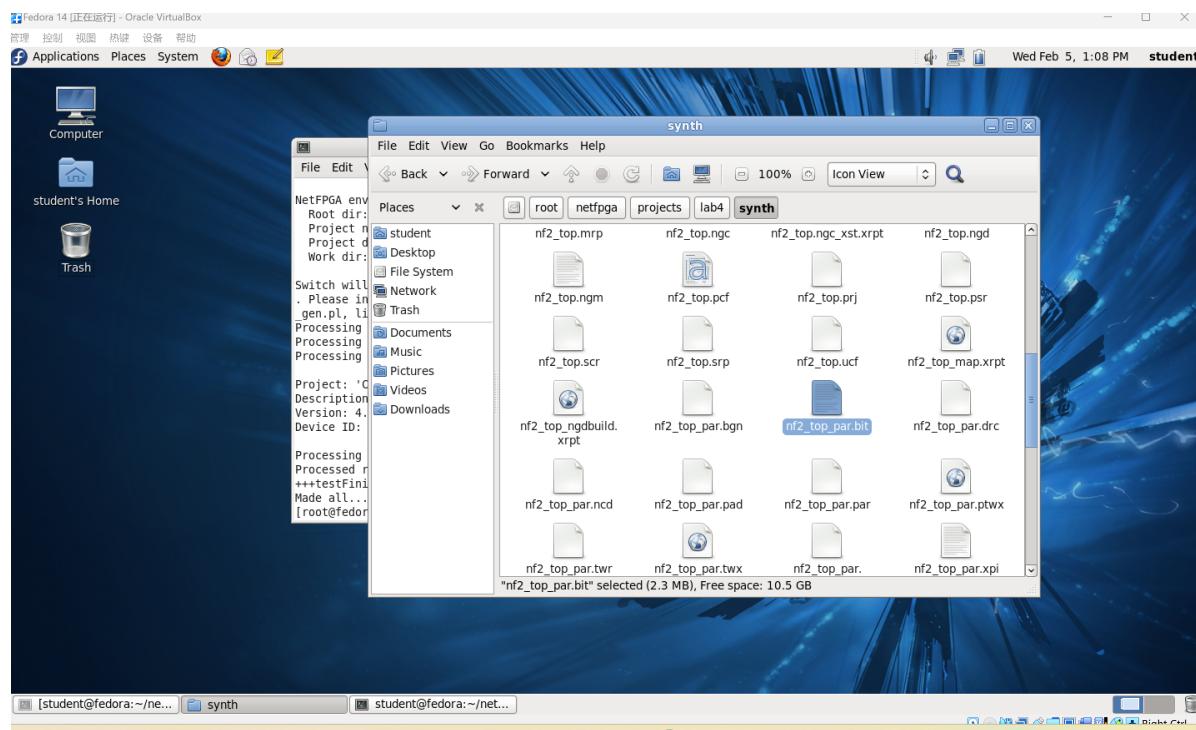
2.2 Copy all of source files within ids_hw into corresponding folders into NetFPGA project folder



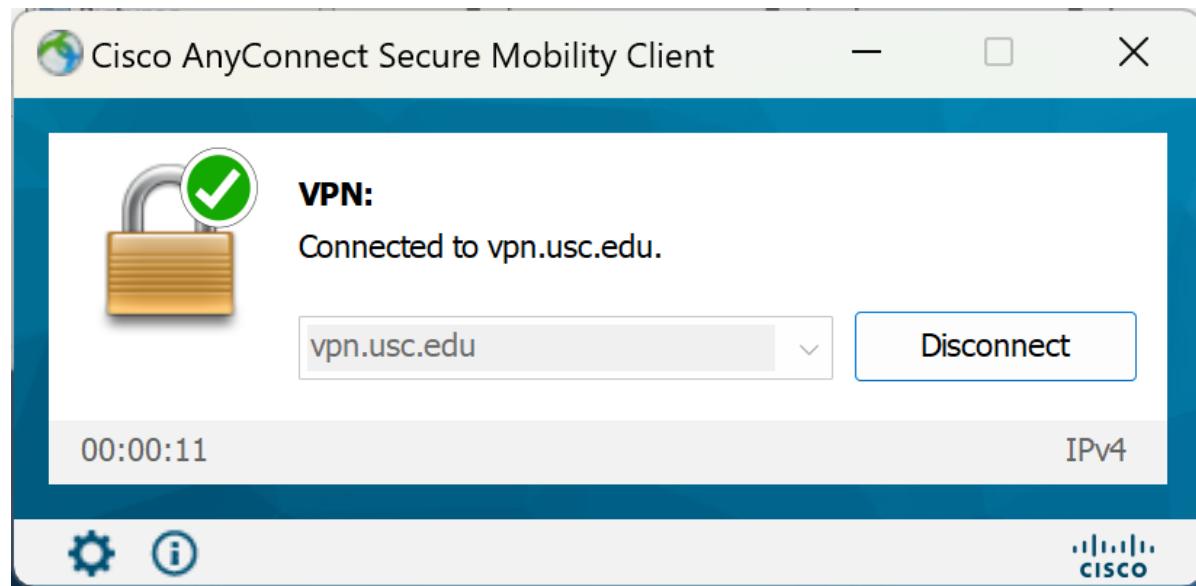
2.3 Compile the design by 'cd' into the synth folder type 'make'



2.4 '*.bit' file generated



3. Set Up VPN to USC



4. NetFPGA Environment

Your NetFPGA username, password would be
team8 4z65jKjbw6c8

Feb 8 18:43

```
clint@clint-VMware-Virtual-Platform:~/Documents$ sudo apt install libssl
[sudo] password for clint:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Note, selecting 'libssl3t64' instead of 'libssl3'
libssl3t64 is already the newest version (3.0.13-0ubuntu3.4).
0 upgraded, 0 newly installed, 0 to remove and 198 not upgraded.
clint@clint-VMware-Virtual-Platform:~/Documents$ cd Documents/
clint@clint-VMware-Virtual-Platform:~/Documents$ ls
Ble533  openterm
clint@clint-VMware-Virtual-Platform:~/Documents$ ./openterm 8 4z65jKjbw6c8
clint@clint-VMware-Virtual-Platform:~/Documents$
```

Virtex design compiled against active CRCTI version

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.

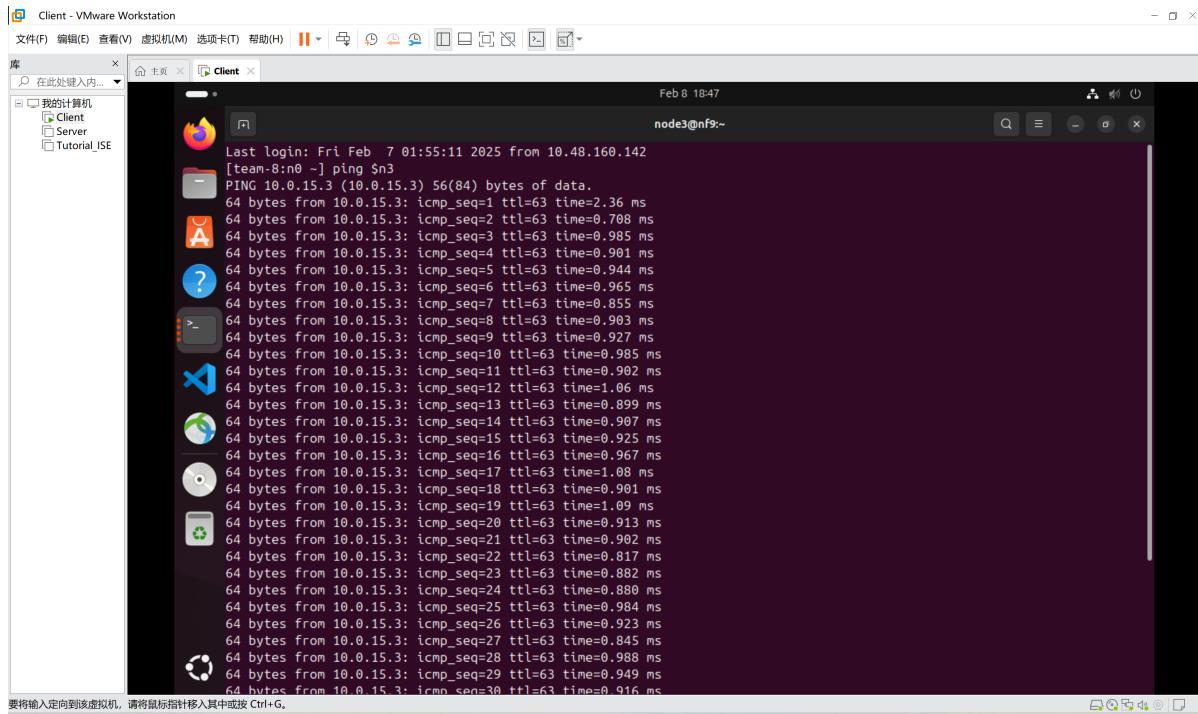
CPCI Information
-----
Version: 4 (rev 1)

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 ~]
```

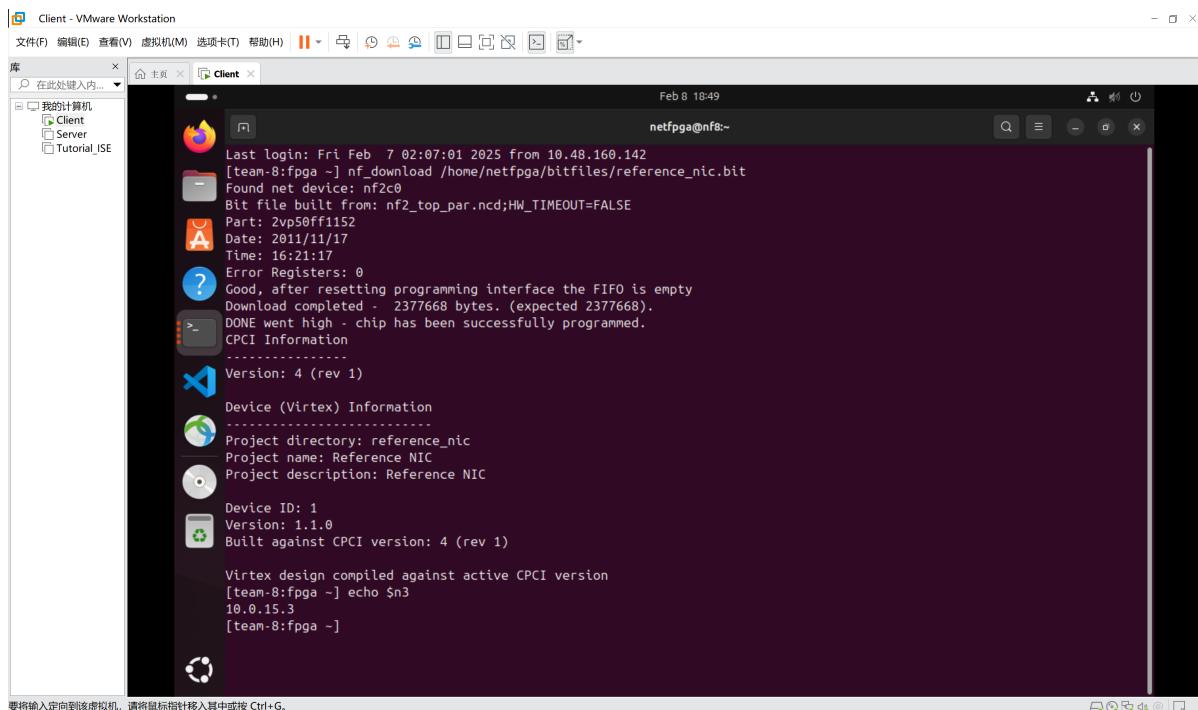
5.2 Test ping from n0 to n3



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

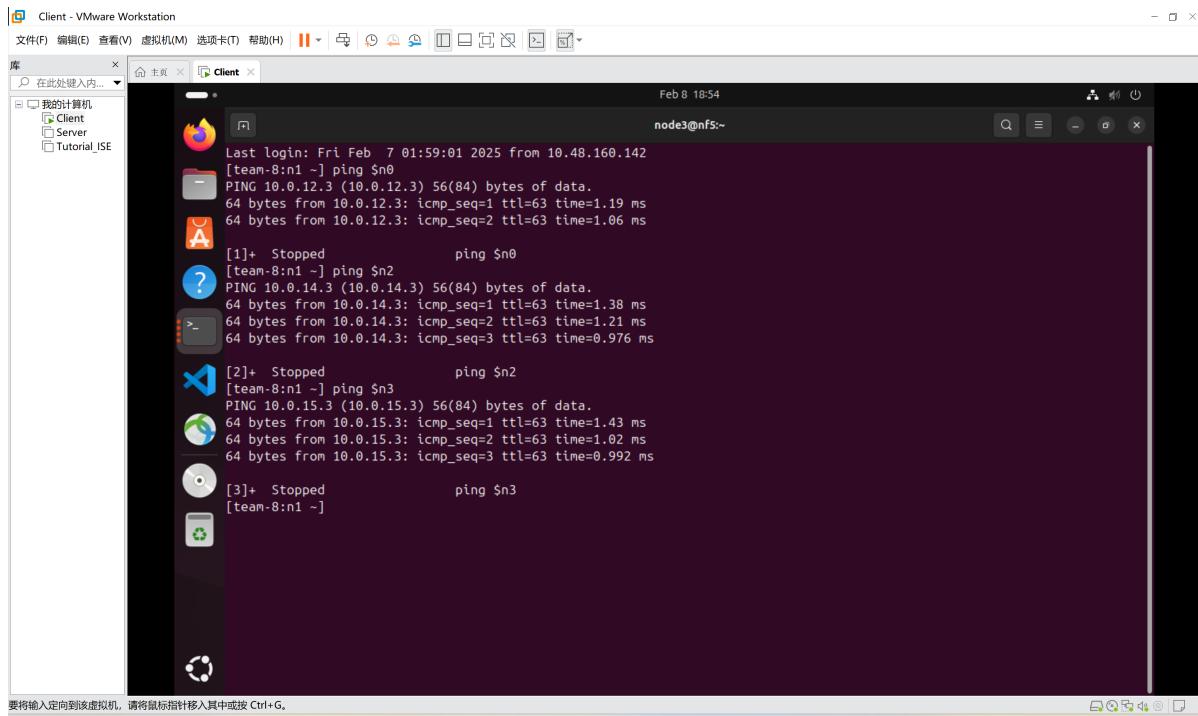
[3]+ Stopped ping $n1
[team-8:n0 ~] ping $n2
PING 10.0.14.3 (10.0.14.3) 56(84) bytes of data.
64 bytes from 10.0.14.3: icmp_seq=1 ttl=63 time=2.16 ms
64 bytes from 10.0.14.3: icmp_seq=2 ttl=63 time=1.07 ms

[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



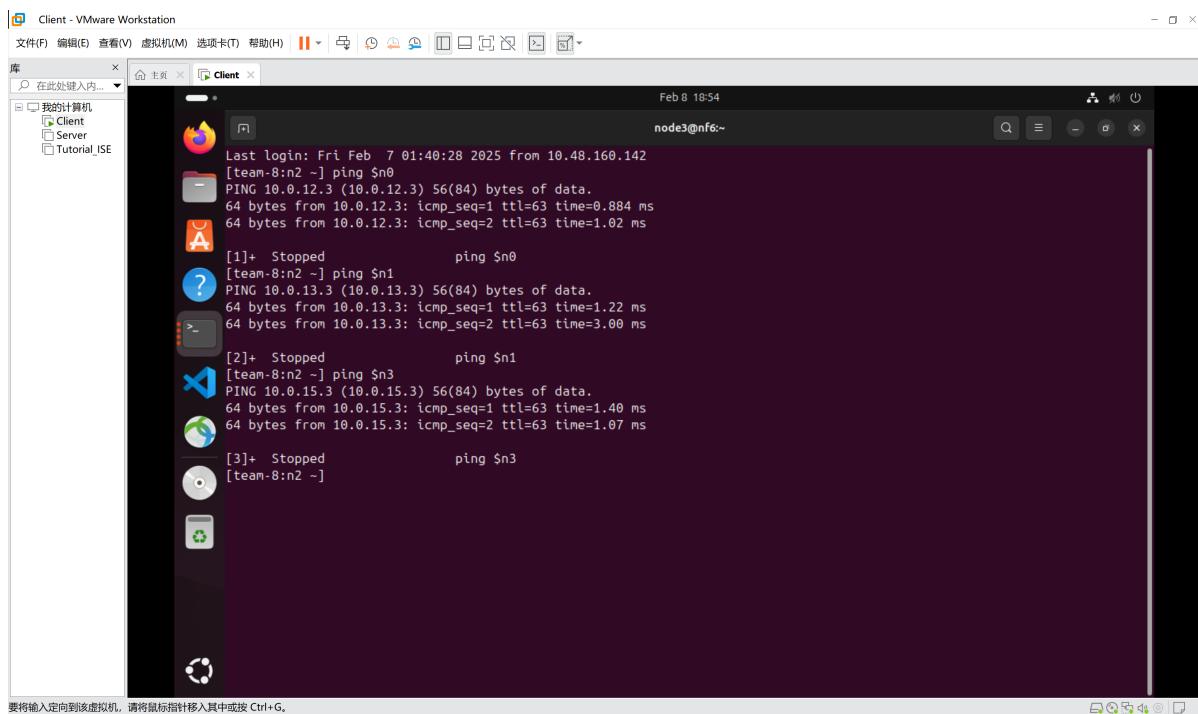
```
Last login: Fri Feb 7 01:59:01 2025 from 10.48.160.142
[team-8:n1 ~] ping $n0
PING 10.0.12.3 (10.0.12.3) 56(84) bytes of data.
64 bytes from 10.0.12.3: icmp_seq=1 ttl=63 time=1.19 ms
64 bytes from 10.0.12.3: icmp_seq=2 ttl=63 time=1.06 ms

[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
[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



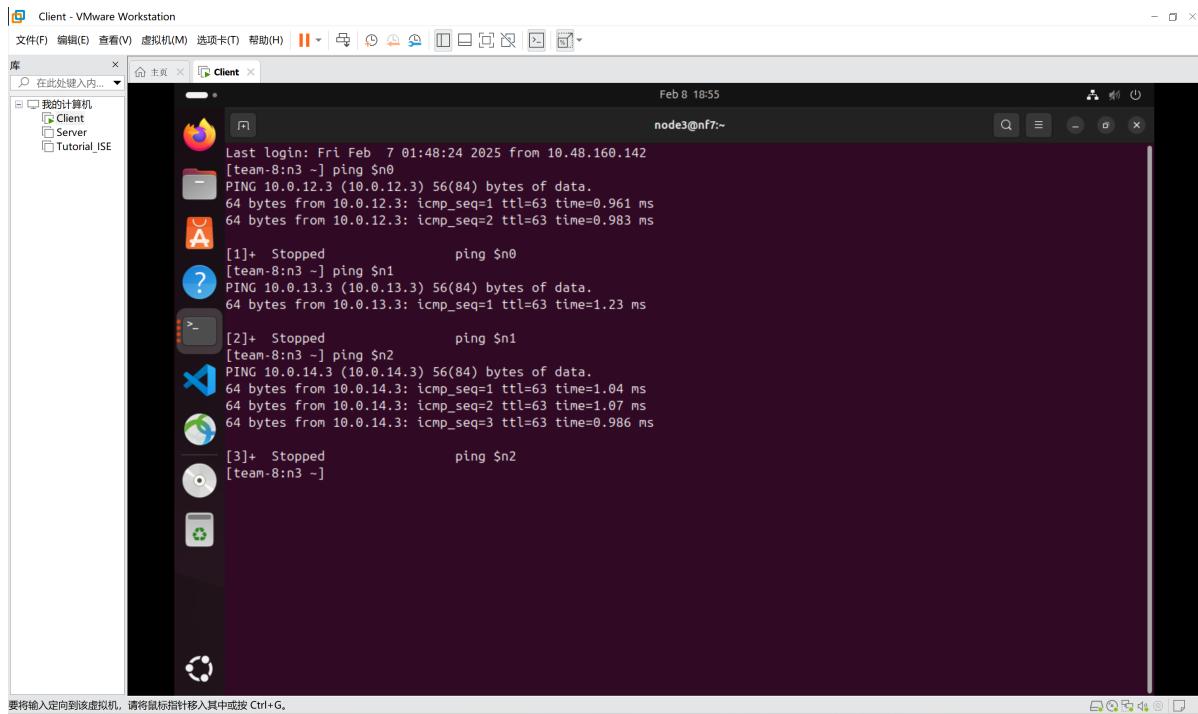
```
Last login: Fri Feb 7 01:40:28 2025 from 10.48.160.142
[team-8:n2 ~] ping $n0
PING 10.0.12.3 (10.0.12.3) 56(84) bytes of data.
64 bytes from 10.0.12.3: icmp_seq=1 ttl=63 time=0.884 ms
64 bytes from 10.0.12.3: icmp_seq=2 ttl=63 time=1.02 ms

[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

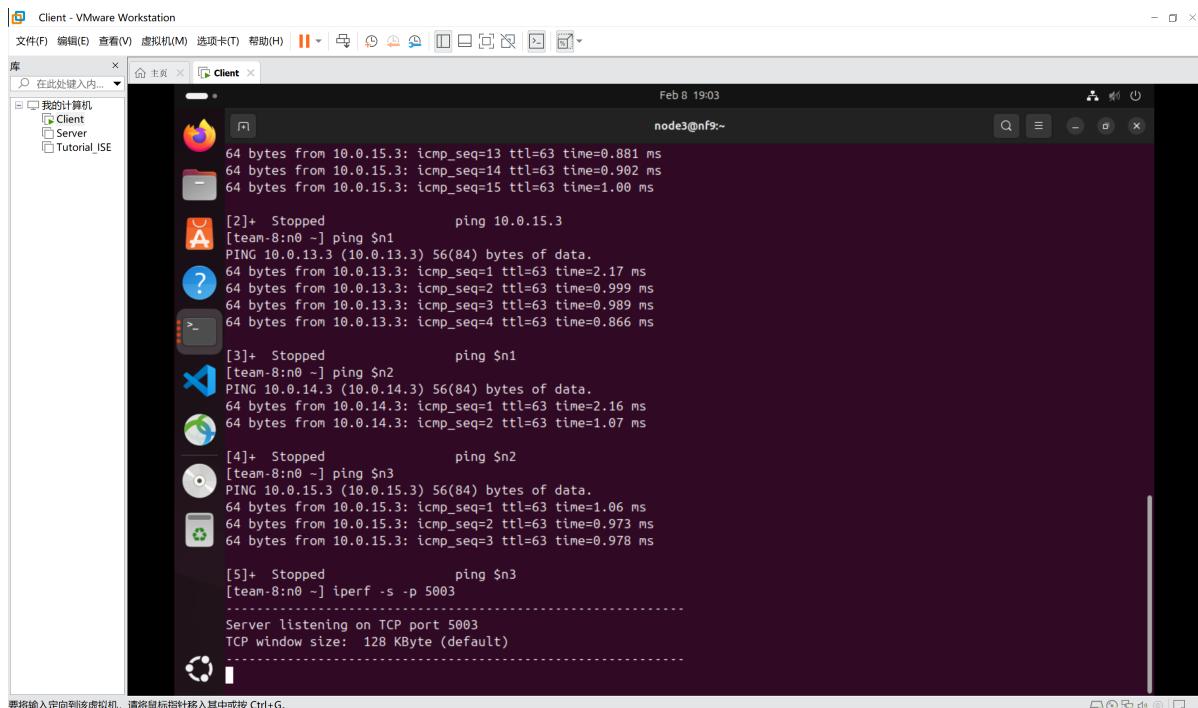
[1]+ Stopped ping $n0
[team-8:n3 ~] ping $n1
PING 10.0.13.3 (10.0.13.3) 56(84) bytes of data.
64 bytes from 10.0.13.3: icmp_seq=1 ttl=63 time=1.23 ms

[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 window title is "Client" and the command run is "[team-8:n0 ~] iperf -s -p 5003". The output of the command is as follows:

```
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

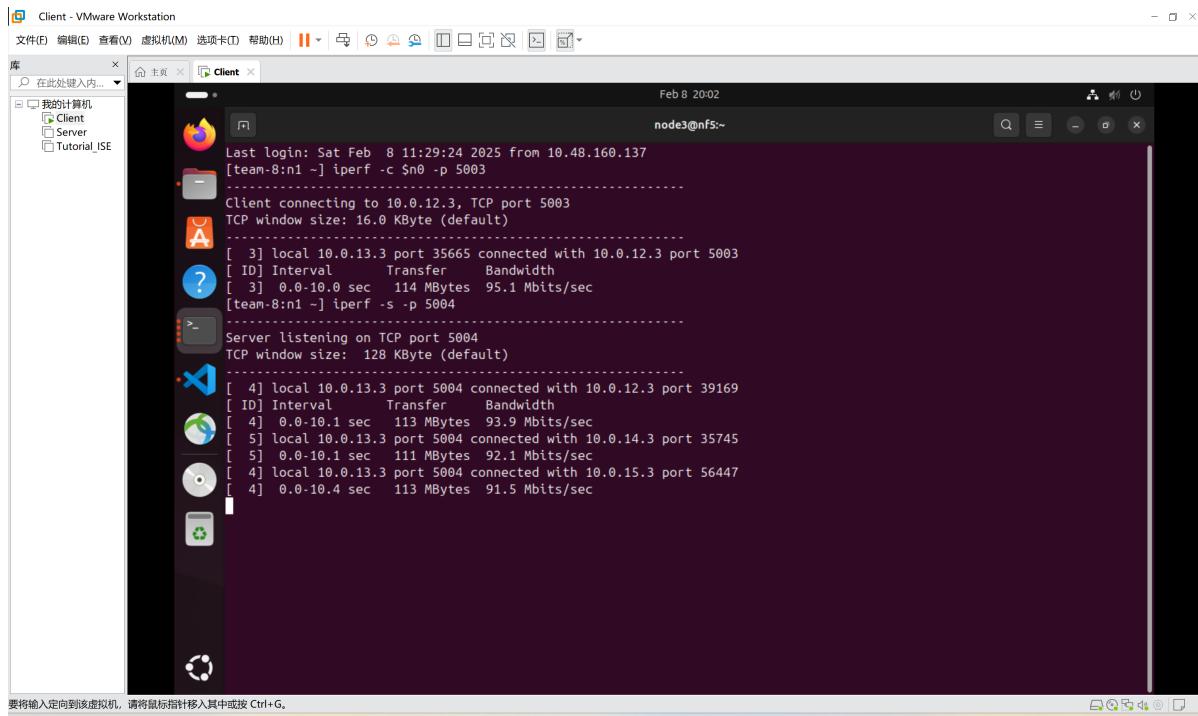
5.6 Test iperf with script

- n0 as TCP server

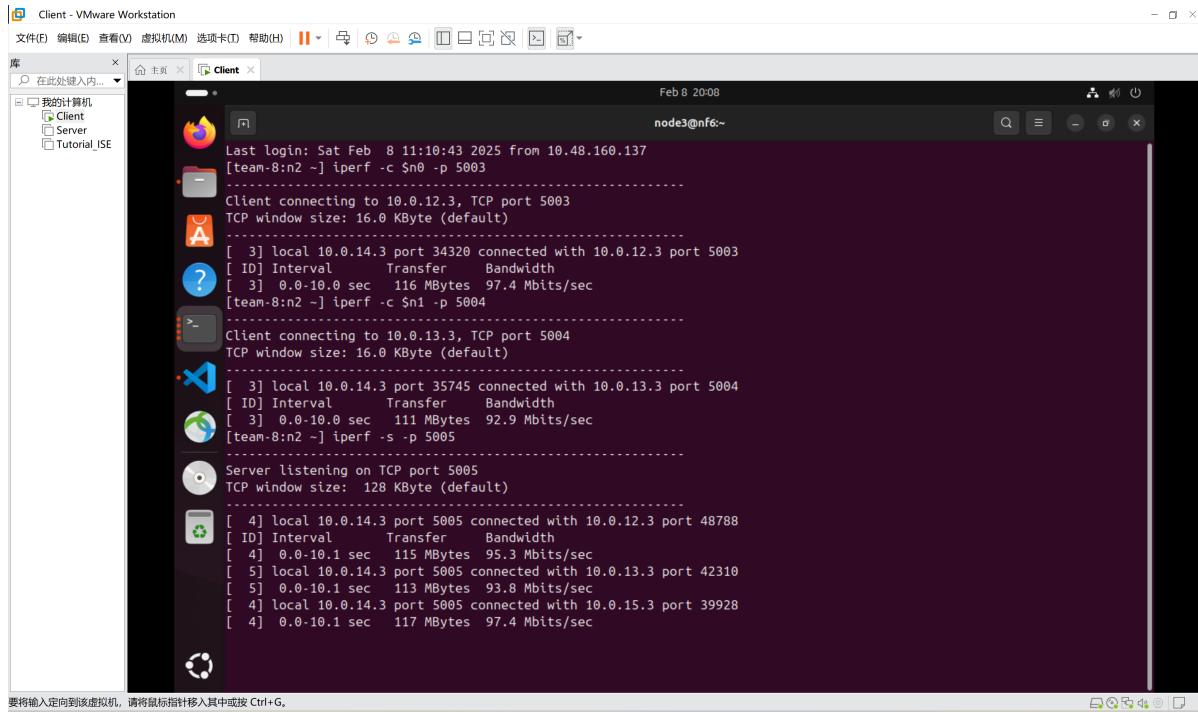
The screenshot shows a terminal window titled 'Client' running on a host machine named 'Client - VMware Workstation'. The terminal session is connected to a node named 'node3@nf9'. The output of the command 'iperf -s -p 5003' is displayed, showing network performance metrics for four connections:

```
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

The screenshot shows a terminal window titled "Client" running on a Windows host. The terminal session is connected to a virtual machine named "Client". The output of the command "netfpga" is displayed, showing the following details:

- 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] Feb 8 20:17
[ 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 MBBytes 94.8 Mbits/sec
[team-8:n0 ~] iperf -c $n2 -p 5005

Client connecting to 10.0.14.3, TCP port 5005
TCP window size: 16.0 KByte (default)
-----
[ 3] local 10.0.12.3 port 48788 connected with 10.0.14.3 port 5005
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 115 MBBytes 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 MBBytes 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 MBBytes 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 MBBytes 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 MBBytes 372 Mbits/sec
```

- 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
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-8:1 ~] iperf -c $n0 -p 5006
-----
[ 3] local 10.0.12.3 port 5000 connected with 10.0.12.3 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-8:1 ~] iperf -s -p 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) |

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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 Mbytes/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 Mbytes/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 40900 connected with 10.0.13.3 port 5001
[ ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 536 MBytes 450 Mbytes/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 Mbytes/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 Mbytes/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 Mbytes/sec
```

- n3 as TCP server

Client - VMware Workstation

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我的计算机

- Client
- Server
- Tutorial.ISE

Client

Feb 8 20:22

node3@nf7:~

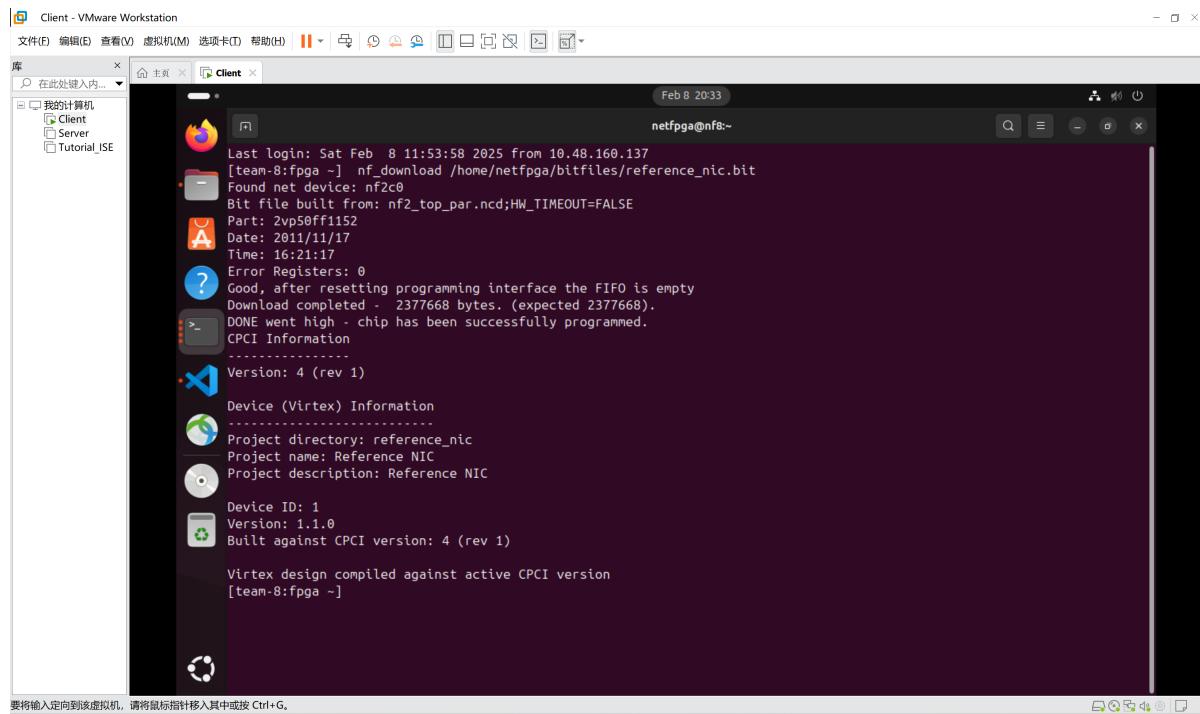
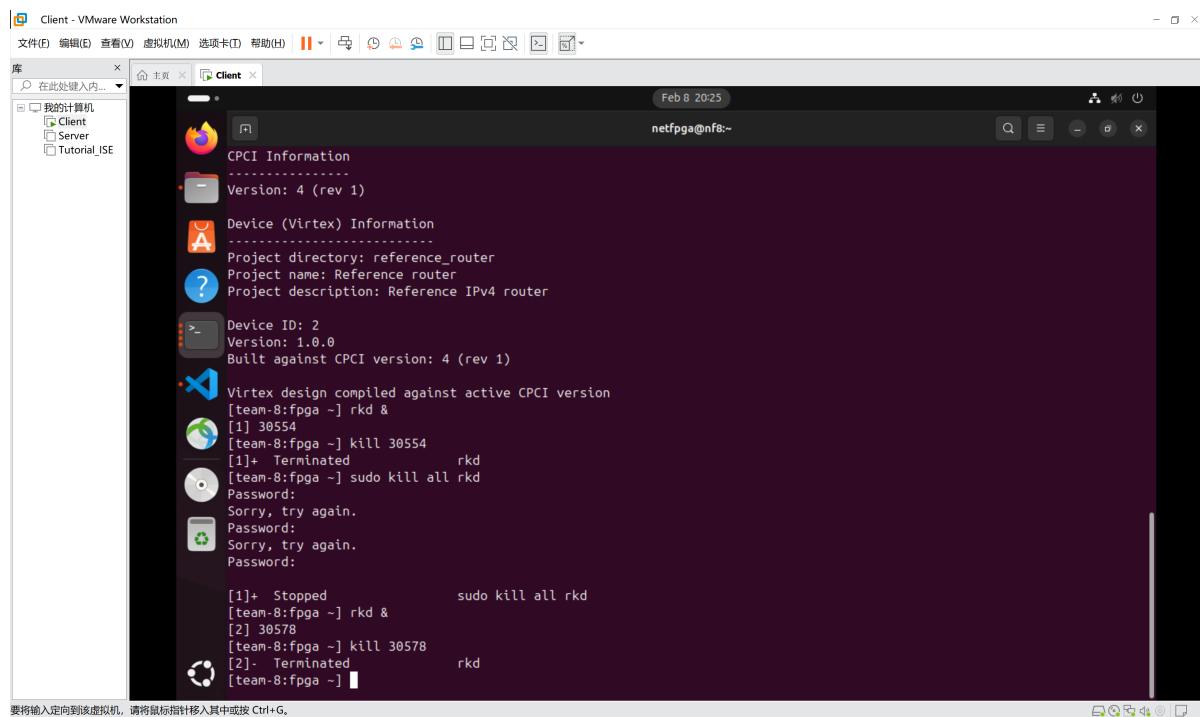
```
[ 3] local 10.0.15.3 port 35179 connected with 10.0.12.3 port 5000
[ ID] Interval      Transfer     Bandwidth
[ 3] 0.0-10.0 sec   445 MBytes   373 Mbits/sec
[team-8:n3 ~] iperf -c $n1 -p 5001
-----
[ A] Client connecting to 10.0.13.3, TCP port 5001
TCP window size: 16.0 KByte (default)
[ 3] local 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
-----
[ A] 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
-----
[ C] 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
```

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 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

Client - VMware Workstation

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

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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

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