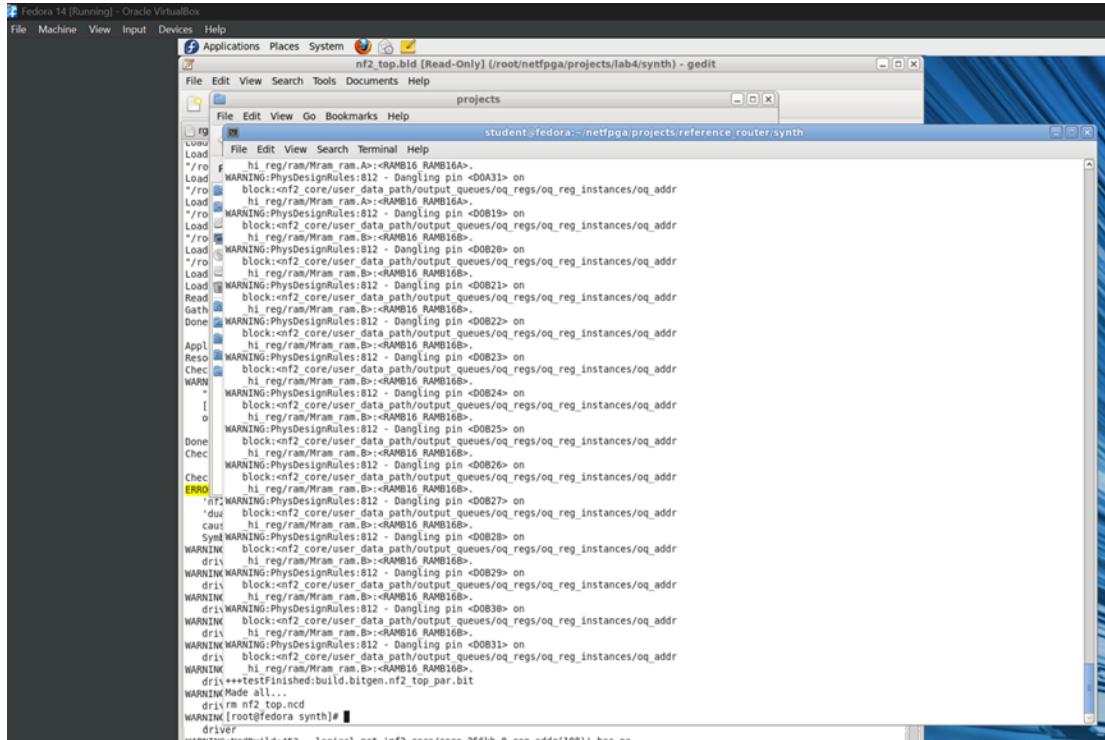
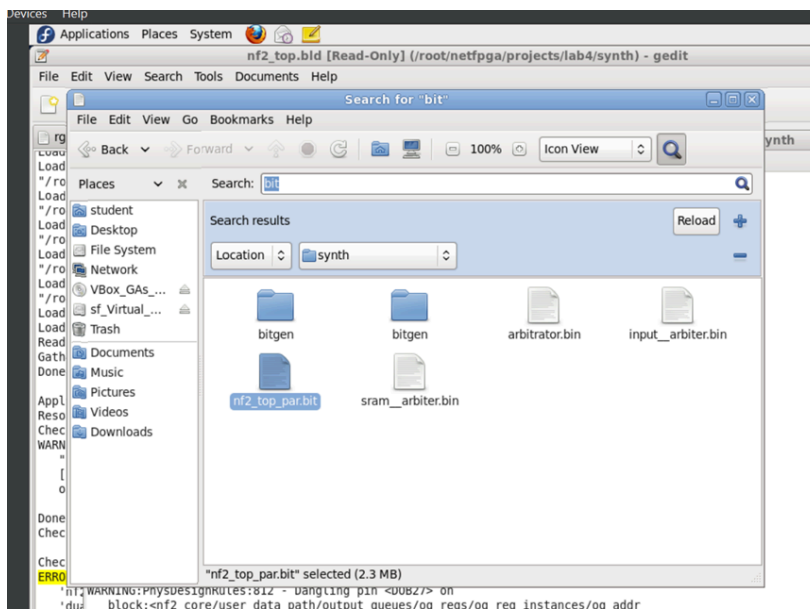


here is the github link to the files that we used and generated in this lab:
https://github.com/yuezhenglingluan/USC_EE533_lab4

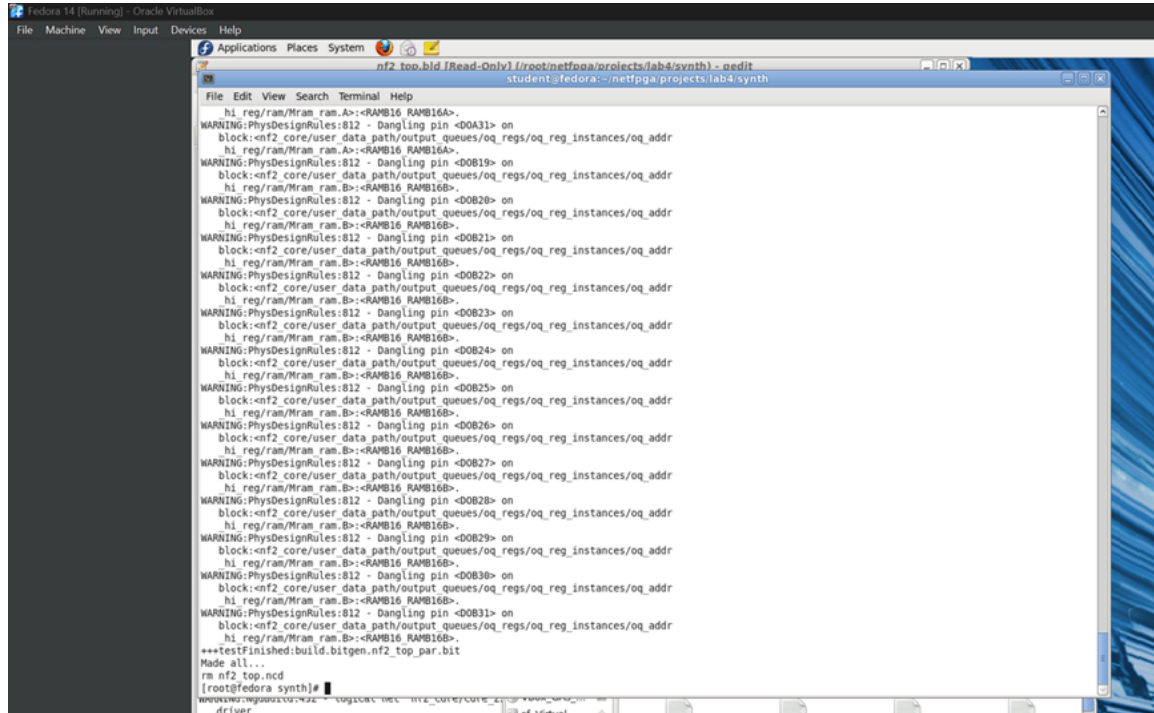
1. Here is the screenshot of the result after running make to generate a bitfile for the reference router:



And here is the generated bit file:



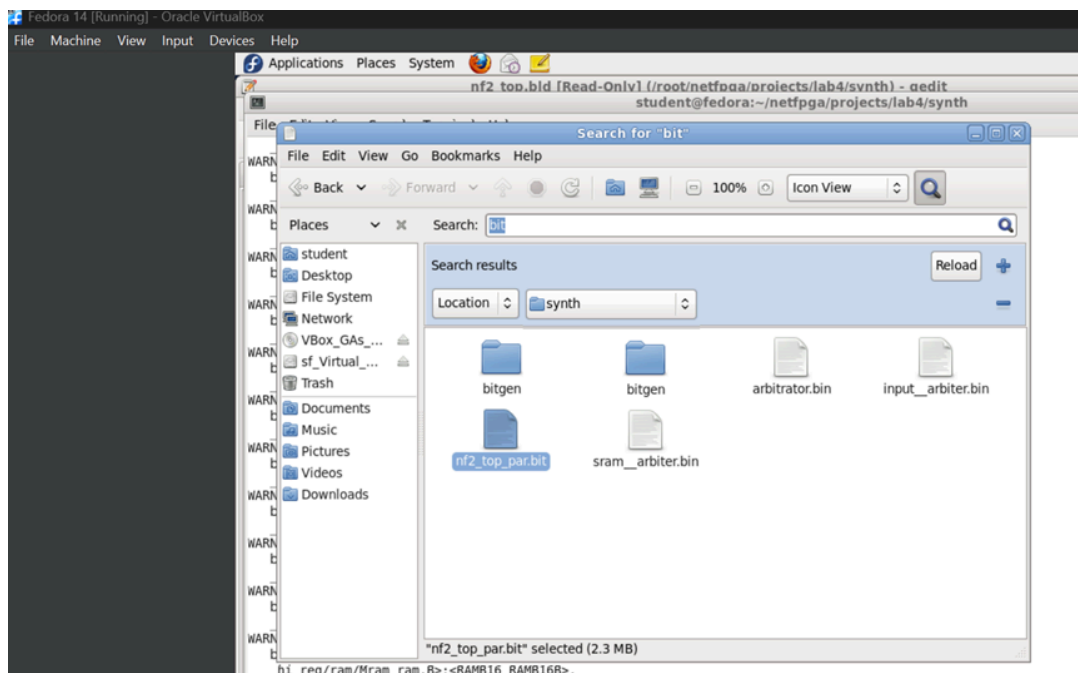
2. here is the screenshot of the result after we copy the .v and .xco file from lab 3 to the src folder and run make in synth to generate a bit file:



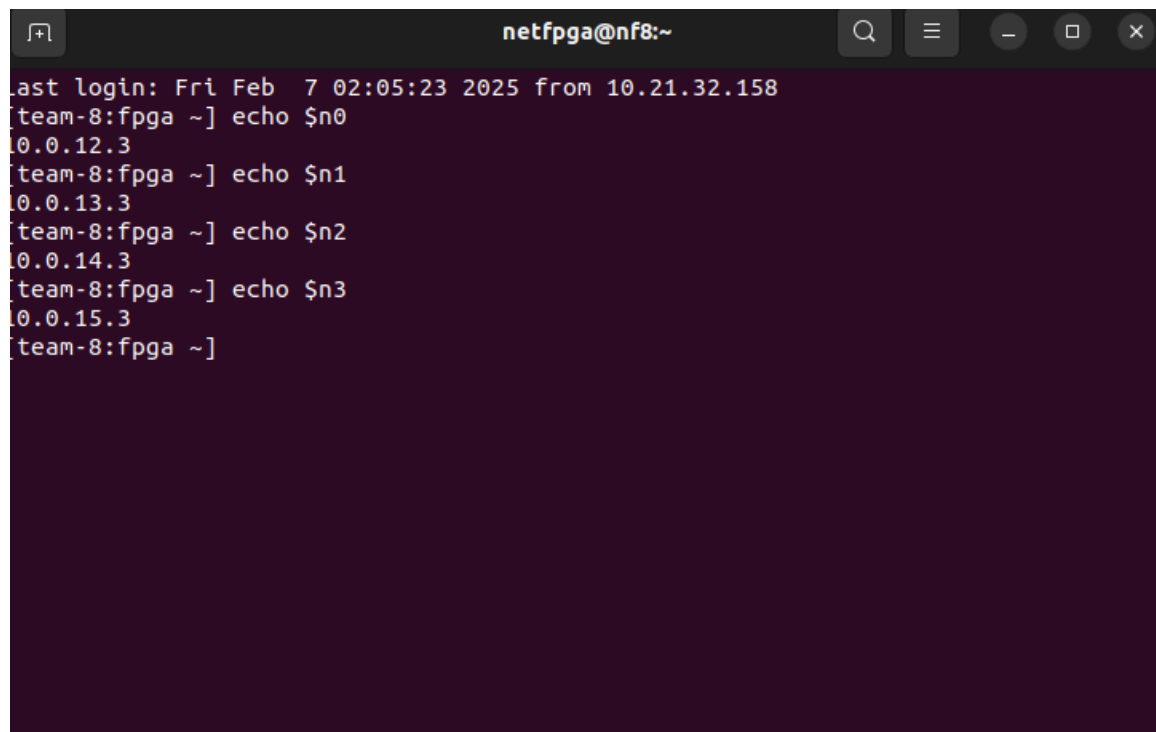
```
nf2_top.bld [Read-Only] (/root/netfpga/projects/lab4/synth) - aedit
student@fedora:~/netfpga/projects/lab4/synth

File Edit View Search Terminal Help
hi reg/ram/Mram ram.A>:<RAMB16 RAMB16A>.
WARNING:PhysDesignRules:812 - Dangling pin <D0A31> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.A>:<RAMB16 RAMB16A>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B19> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B20> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B21> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B22> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B23> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B24> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B25> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B26> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B27> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B28> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B29> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B30> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
WARNING:PhysDesignRules:812 - Dangling pin <D0B31> on
block:cnf2_core/user_data_path/output_queues/oq_regs/oq_addr
hi reg/ram/Mram ram.B>:<RAMB16 RAMB16B>.
+++test finished:build.bitgen.nf2_top_par.bit
Made all...
rm nf2_top.ncd
[root@fedora synth]#
```

And here is the generated bit file:



Echo each node from fpga



```
netfpga@nf8:~  
last login: Fri Feb  7 02:05:23 2025 from 10.21.32.158  
team-8:fpga ~] echo $n0  
0.0.12.3  
team-8:fpga ~] echo $n1  
0.0.13.3  
team-8:fpga ~] echo $n2  
0.0.14.3  
team-8:fpga ~] echo $n3  
0.0.15.3  
team-8:fpga ~]
```

reference router test

```
netfpga@nf8:~  
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 ~]
```

ping test

```
node3@nf6:~  
Last login: Fri Feb 7 01:38:51 2025 from 10.21.32.158  
[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=3.70 ms  
64 bytes from 10.0.15.3: icmp_seq=2 ttl=63 time=0.975 ms  
64 bytes from 10.0.15.3: icmp_seq=3 ttl=63 time=0.960 ms  
64 bytes from 10.0.15.3: icmp_seq=4 ttl=63 time=0.967 ms  
  
--- 10.0.15.3 ping statistics ---  
4 packets transmitted, 4 received, 0% packet loss, time 3001ms  
rtt min/avg/max/mdev = 0.960/1.650/3.700/1.183 ms  
[team-8:n2 ~]
```

The image displays a collage of terminal windows from a Linux desktop environment, illustrating the configuration and testing of a secure connection between two virtual machines (VMs) using `sshpass` and `socat`.

- Top Left Terminal (node3@nf2):** Shows the execution of `iperrf -s` and `ifconfig`. The `ifconfig` command indicates that the `eth0` interface is up and has an IP address of `10.0.1.1`.
- Top Right Terminal (node3@nf7):** Shows the execution of `sshpass` and `socat`. The `socat` command is used to establish a connection between the two VMs.
- Middle Left Terminal (node3@nf2):** Shows the execution of `sshpass` and `socat`. The `socat` command is used to establish a connection between the two VMs.
- Middle Right Terminal (node3@nf6):** Shows the execution of `sshpass` and `socat`. The `socat` command is used to establish a connection between the two VMs.
- Bottom Left Terminal (node3@nf2):** Shows the execution of `sshpass` and `socat`. The `socat` command is used to establish a connection between the two VMs.
- Bottom Right Terminal (node3@nf6):** Shows the execution of `sshpass` and `socat`. The `socat` command is used to establish a connection between the two VMs.

The terminal windows also show the output of various commands, including the IP addresses of the interfaces, the status of the connections, and the results of the `socat` tests.

```
node3@nfs:~  
last login: Fri Feb 7 01:57:27 2025 from 10.21.32.158  
[team-8:n1 ~] iperf3 -s  
bash: iperf3: command not found  
[team-8:n1 ~] iperf -s  
-----  
server listening on TCP port 5001  
TCP window size: 128 KByte (default)  
-----  
[team-8:n1 ~]  
[team-8:n1 ~] ifconfig  
bash: ifconfig: command not found  
[team-8:n1 ~] iperf -s  
-----  
server listening on TCP port 5001  
TCP window size: 128 KByte (default)  
-----  
[ 4] local 10.0.13.3 port 5001 connected with 10.0.13.2 port 49415  
[ID] Interval Transfer Bandwidth  
[ 4] 0.0-10.1 sec 168 MBytes 139 Mbits/sec  
-----  
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 ~] iperf -c 10.0.12.3  
-----  
Client connecting to 10.0.12.3, TCP port 5001  
TCP window size: 16.0 KByte (default)  
-----  
[ 3] local 10.0.12.2 port 4892 connected with 10.0.12.3 port 5001  
[ID] Interval Transfer Bandwidth  
[ 3] 0.0-10.0 sec 164 MBytes 137 Mbits/sec  
[team-8:fpga ~] iperf -c 10.0.13.3  
-----  
Client connecting to 10.0.13.3, TCP port 5001  
TCP window size: 16.0 KByte (default)  
-----  
[ 3] local 10.0.13.2 port 49415 connected with 10.0.13.3 port 5001  
[ID] Interval Transfer Bandwidth  
[ 3] 0.0-10.0 sec 168 MBytes 140 Mbits/sec  
[team-8:fpga ~]
```

```
node3@n2:~$
st login: Fri Feb 7 01:38:51 2025 from 10.21.32.158
eam-8:n2 ~] ping 5n3
NG 10.0.15.3: 10.0.15.3: 56(84) bytes of data.
bytes from 10.0.15.3: icmp_seq=1 ttl=63 time=0.370 ms
bytes from 10.0.15.3: icmp_seq=2 ttl=63 time=0.975 ms
bytes from 10.0.15.3: icmp_seq=3 ttl=63 time=0.960 ms
bytes from 10.0.15.3: icmp_seq=4 ttl=63 time=0.967 ms

- 10.0.15.3 ping statistics ---
packets transmitted, 4 received, 0% packet loss, time 3001ms
rt min/avg/max/mdev = 0.960/1.650/3.706/1.183 ms
eam-8:n2 ~] iperf3 -s
ash: iperf3: command not found
eam-8:n2 ~] iperf -s
-----
rver listening on TCP port 5001
P window size: 128 KByte (default)
-----
[ 3] local 10.0.14.3 port 5001 connected with 10.0.14.2 port 41862
[ID] Interval Transfer Bandwidth
[ 3] 0.0-10.2 sec 167 MBytes 138 Mb/s/sec

-----
Client connecting to 10.0.12.3, TCP port 5001
TCP window size: 16.0 KByte (default)
-----
[ 3] local 10.0.12.2 port 43892 connected with 10.0.12.3 port 5001
[ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 164 MBytes 137 Mb/s/sec
[team-8:fpga ~] iperf -c 10.0.13.3
-----
Client connecting to 10.0.13.3, TCP port 5001
TCP window size: 16.0 KByte (default)
-----
[ 3] local 10.0.13.2 port 49415 connected with 10.0.13.3 port 5001
[ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 168 MBytes 140 Mb/s/sec
[team-8:fpga ~] iperf -c 10.0.14.3
-----
Client connecting to 10.0.14.3, TCP port 5001
TCP window size: 16.0 KByte (default)
-----
[ 3] local 10.0.14.2 port 41862 connected with 10.0.14.3 port 5001
[ID] Interval Transfer Bandwidth
[ 3] 0.0-10.0 sec 167 MBytes 140 Mb/s/sec
[team-8:fpga ~]
```

iperf test node to node

```
node3@nf6:~  
64 bytes from 10.0.15.3: icmp_seq=4 ttl=63 time=0.967 ms  
--- 10.0.15.3 ping statistics ---  
4 packets transmitted, 4 received, 0% packet loss, time 300ms  
rtt min/avg/max/mdev = 0.960/1.650/3.700/1.183 ms  
[team-8:n2 ~] iperf3 -s  
-bash: iperf3: command not found  
[team-8:n2 ~] iperf -s  
-----  
Server listening on TCP port 5001  
TCP window size: 128 KByte (default)  
-----  
[ 4] local 10.0.14.3 port 5001 connected with 10.0.14.2 port 41862  
[ ID] Interval      Transfer    Bandwidth  
[ 4] 0.0-10.2 sec  167 MBytes  138 Mbits/sec  
[team-8:n2 ~] iperf -s  
-----  
Server listening on TCP port 5001  
TCP window size: 128 KByte (default)  
-----  
[ 4] local 10.0.14.3 port 5001 connected with 10.0.15.3 port 59859  
[ ID] Interval      Transfer    Bandwidth  
[ 4] 0.0-10.1 sec  114 MBytes  94.4 Mbits/sec
```

```
node3@nf7:~  
Last login: Fri Feb 7 01:46:50 2025 from 10.21.32.158  
[team-8:n3 ~] iperf -c 10.0.14.3  
-----  
Client connecting to 10.0.14.3, TCP port 5001  
TCP window size: 16.0 KByte (default)  
-----  
[ 3] local 10.0.15.3 port 59859 connected with 10.0.14.3 port 5001  
[ ID] Interval      Transfer    Bandwidth  
[ 3] 0.0-10.0 sec  114 MBytes  95.2 Mbits/sec  
[team-8:n3 ~]
```

```
node3@nf5:~  
-----  
Server listening on TCP port 5001  
TCP window size: 128 KByte (default)  
-----  
[team-8:n1 ~]  
[team-8:n1 ~] ifconfig  
-bash: ifconfig: command not found  
[team-8:n1 ~] iperf -s  
-----  
Server listening on TCP port 5001  
TCP window size: 128 KByte (default)  
-----  
[ 4] local 10.0.13.3 port 5001 connected with 10.0.13.2 port 49415  
[ ID] Interval      Transfer    Bandwidth  
[ 4] 0.0-10.1 sec  168 MBytes  139 Mbits/sec  
[team-8:n1 ~] iperf -s  
-----  
Server listening on TCP port 5001  
TCP window size: 128 KByte (default)  
-----  
[ 4] local 10.0.13.3 port 5001 connected with 10.0.15.3 port 60640  
[ ID] Interval      Transfer    Bandwidth  
[ 4] 0.0-10.1 sec  114 MBytes  94.6 Mbits/sec
```

```
node3@nf7:~  
Last login: Fri Feb 7 01:46:50 2025 from 10.21.32.158  
[team-8:n3 ~] iperf -c 10.0.14.3  
-----  
Client connecting to 10.0.14.3, TCP port 5001  
TCP window size: 16.0 KByte (default)  
-----  
[ 3] local 10.0.15.3 port 59859 connected with 10.0.14.3 port 5001  
[ ID] Interval      Transfer    Bandwidth  
[ 3] 0.0-10.0 sec  114 MBytes  95.2 Mbits/sec  
[team-8:n3 ~] iperf -c 10.0.13.3  
-----  
Client connecting to 10.0.13.3, TCP port 5001  
TCP window size: 16.0 KByte (default)  
-----  
[ 3] local 10.0.15.3 port 60640 connected with 10.0.13.3 port 5001  
[ ID] Interval      Transfer    Bandwidth  
[ 3] 0.0-10.0 sec  114 MBytes  95.4 Mbits/sec  
[team-8:n3 ~]
```

```
node3@nf9:~  
Last login: Fri Feb 7 01:53:38 2025 from 10.21.32.158  
[team-8:n0 ~] iperf -s  
-----  
Server listening on TCP port 5001  
TCP window size: 128 KByte (default)  
-----  
[ 4] local 10.0.12.3 port 5001 connected with 10.0.12.2 port 43892  
[ ID] Interval      Transfer    Bandwidth  
[ 4] 0.0-10.1 sec  164 MBytes  136 Mbits/sec  
[team-8:n0 ~] iperf -s  
-----  
Server listening on TCP port 5001  
TCP window size: 128 KByte (default)  
-----  
[ 4] local 10.0.12.3 port 5001 connected with 10.0.13.3 port 45451  
[ ID] Interval      Transfer    Bandwidth  
[ 4] 0.0-10.1 sec  115 MBytes  95.4 Mbits/sec
```

```
node3@nf5:~  
TCP window size: 128 KByte (default)  
-----  
[ 4] local 10.0.13.3 port 5001 connected with 10.0.13.2 port 49415  
[ ID] Interval      Transfer    Bandwidth  
[ 4] 0.0-10.1 sec  168 MBytes  139 Mbits/sec  
[team-8:n1 ~] iperf -s  
-----  
Server listening on TCP port 5001  
TCP window size: 128 KByte (default)  
-----  
[ 4] local 10.0.13.3 port 5001 connected with 10.0.15.3 port 60640  
[ ID] Interval      Transfer    Bandwidth  
[ 4] 0.0-10.1 sec  114 MBytes  94.6 Mbits/sec  
[team-8:n1 ~] iperf -c 10.0.12.2  
connect failed: Connection refused  
[team-8:n1 ~] iperf -c 10.0.12.3  
-----  
Client connecting to 10.0.12.3, TCP port 5001  
TCP window size: 16.0 KByte (default)  
-----  
[ 3] local 10.0.13.3 port 45451 connected with 10.0.12.3 port 5001  
[ ID] Interval      Transfer    Bandwidth  
[ 3] 0.0-10.0 sec  115 MBytes  96.1 Mbits/sec  
[team-8:n1 ~]
```