EE533_lab4

1. Generating bit files

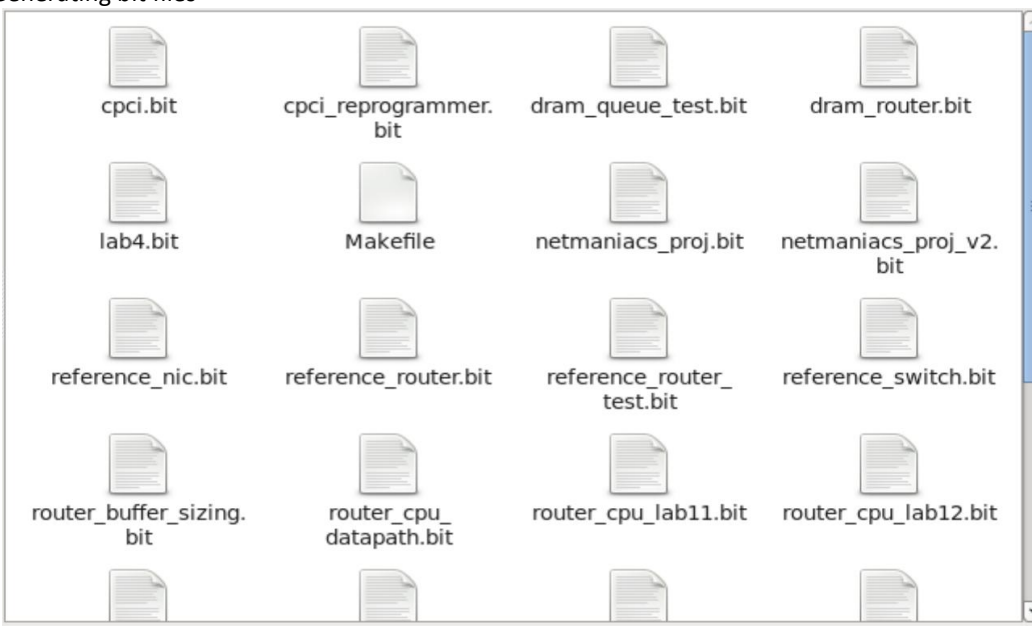

Fig.1.1 bitfiles

2. Setting up NetFPGA Environment

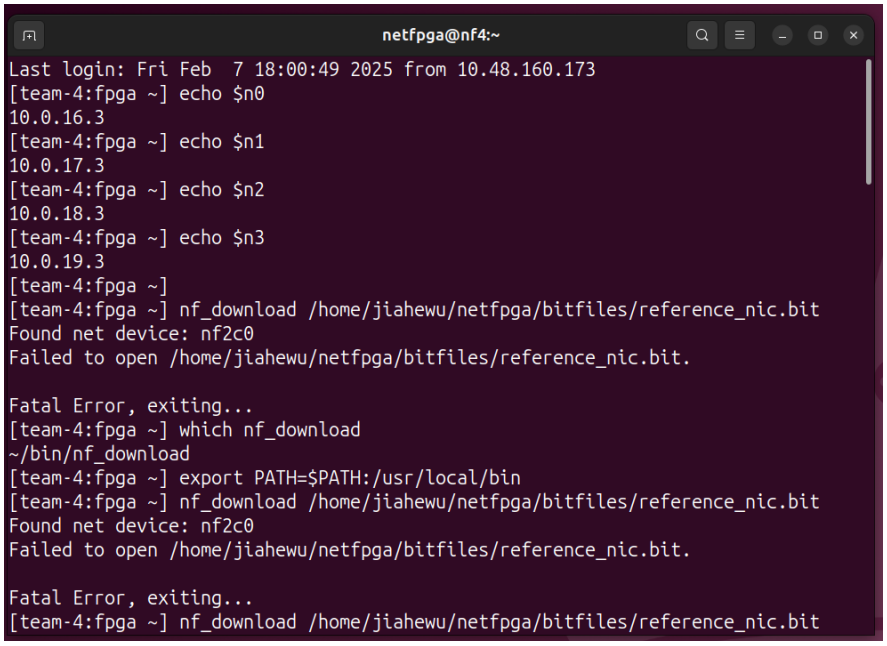

Fig.2.1 NetFPGA node

3. Iperf tests for bandwidth between nodes

We used Python to generate 5 figures showing the bandwidth versus time interval between different tests.

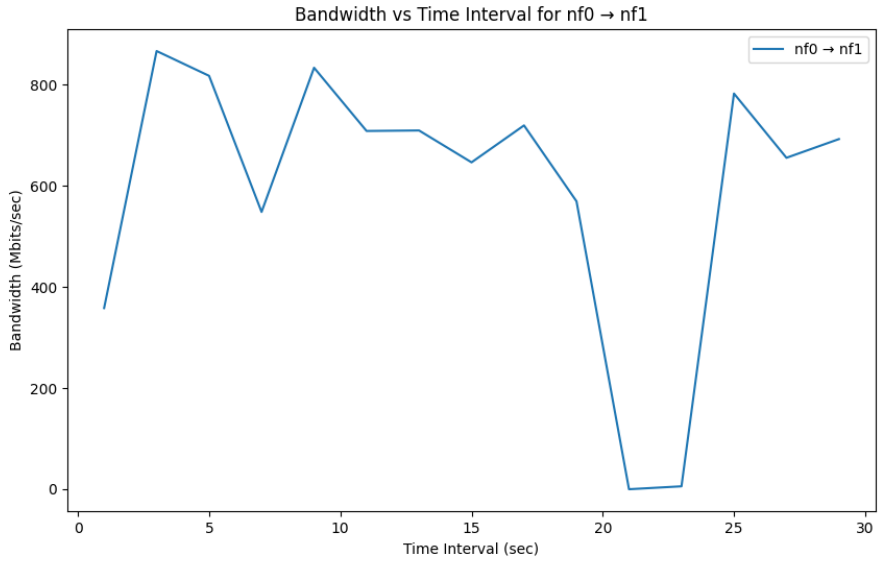

Fig.3.1 nf0->nf1

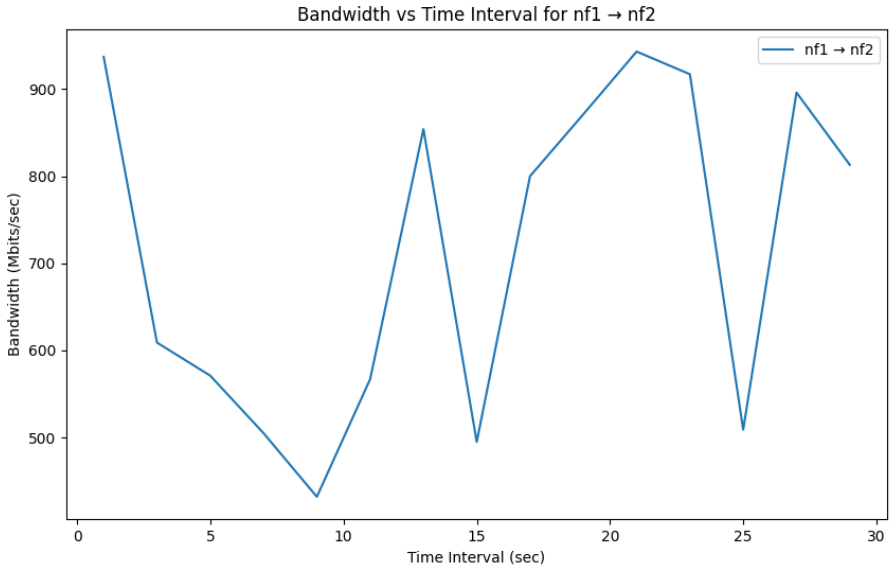

Fig.3.2 nf1->nf2

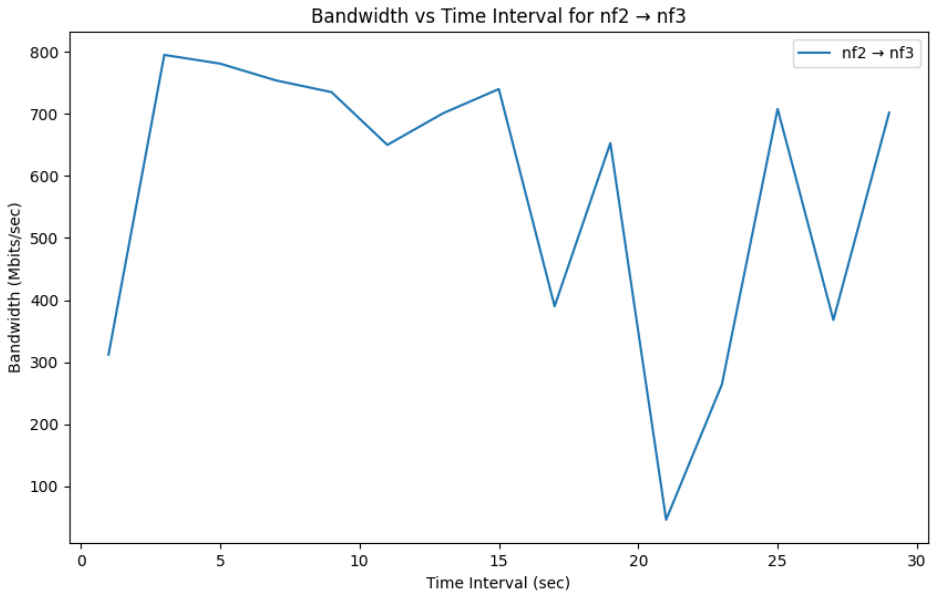

Fig.3.3 nf2->nf3

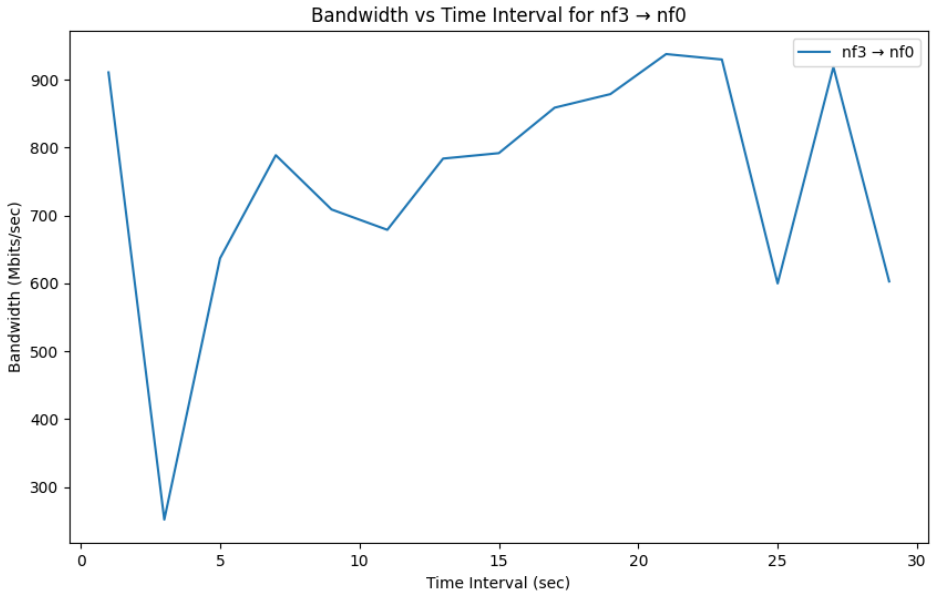

Fig.3.4 nf3->nf0

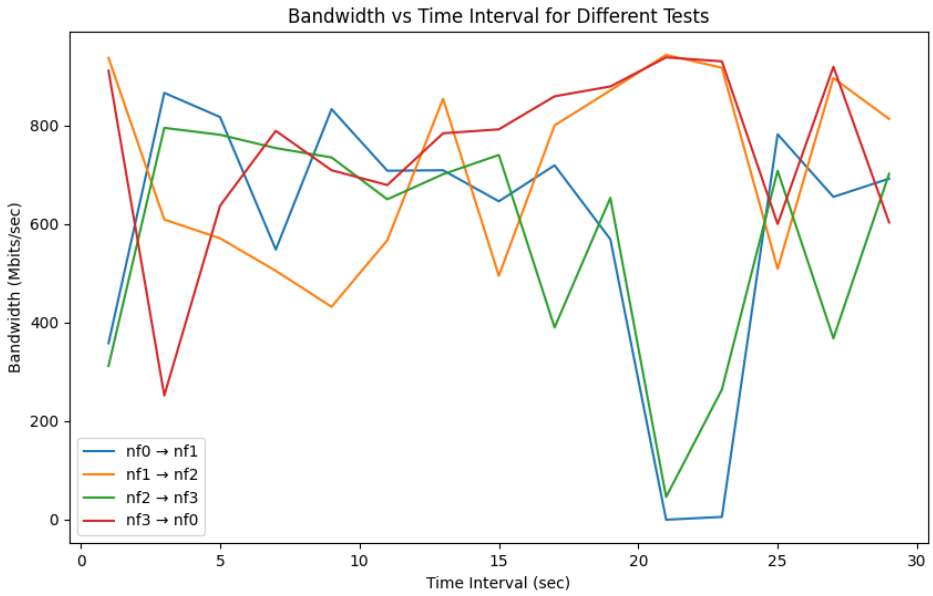

Fig.3.5 Different Tests Comparsion

From the figures 3.1-3.5 above, we can find that the bandwidth of all of the 4 tests fluctuates greatly over time. However, the fluctuation from nf1 to nf2 and from nf3 to nf0 is a little better than the other two tests.

Table 3.1 Average and Standard Deviation of Bandwidth between different Tests(NIC)

Test	Average Bandwidth(Mbits/sec)	Standard Deviation(Mbits/sec)
nf0->nf1	593.85	262.21
nf1->nf2	714.60	183.34
nf2->nf3	573.27	225.06
nf3->nf0	752.07	176.40

According to the table 3.1 above, we can also find that the connection performance of nf1->nf2 and nf3->nf0 is much better than the other two ones from the perspectives of the average and standard deviation of bandwidth.

4. NetFPGA Hardware IP Router

1) Iperf tests for NetFPGA Router

After loading the reference router into the NetFPGA, following figures show the change of bandwidth.

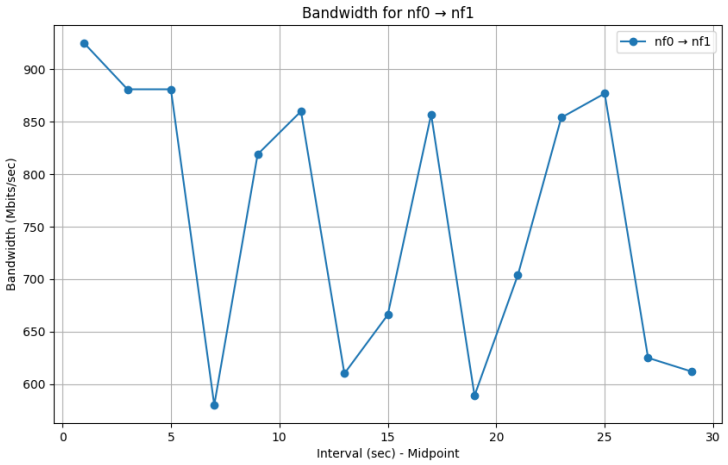

Fig.4.1.1 nf0->nf1

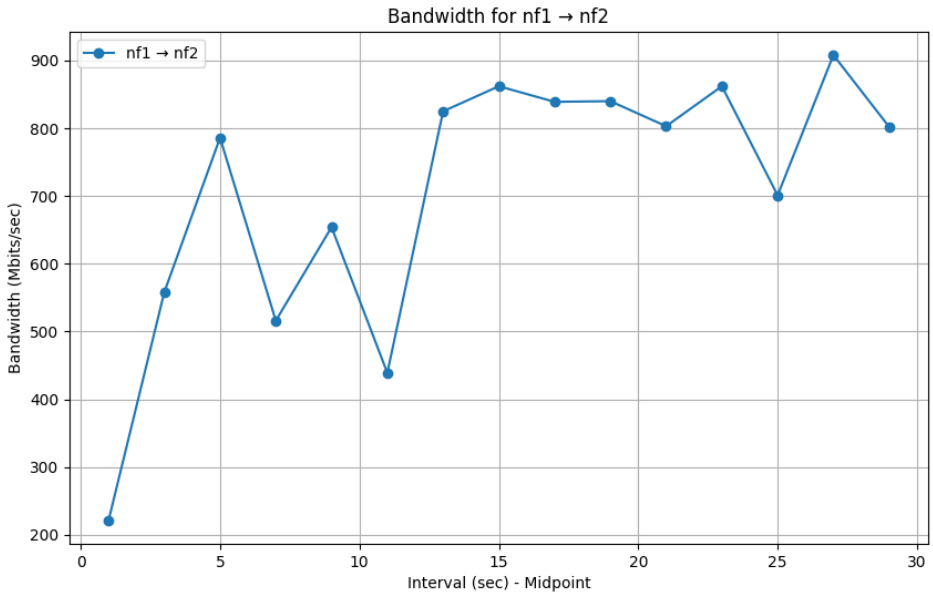

Fig.4.1.2 nf1->nf2

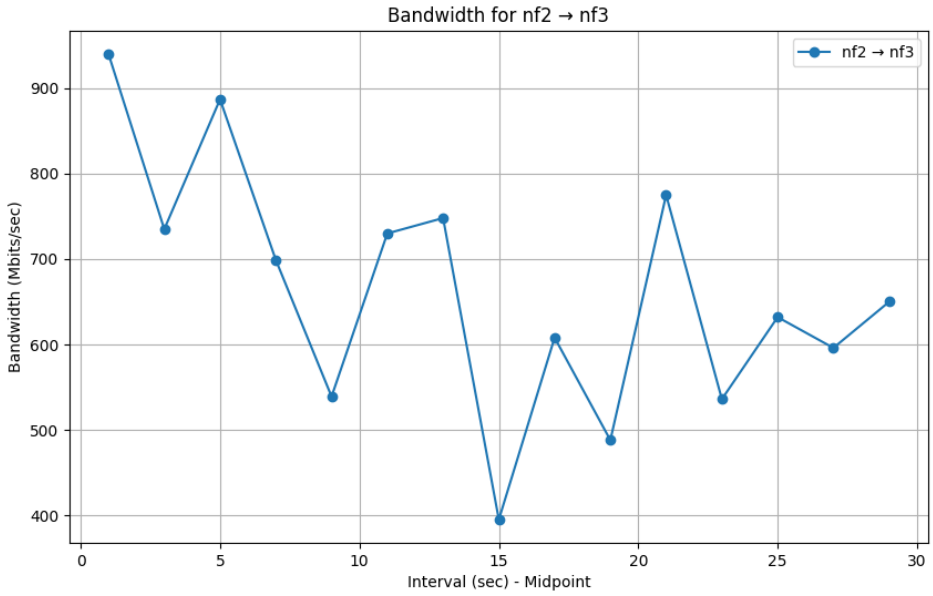

Fig.4.1.3 nf2->nf3

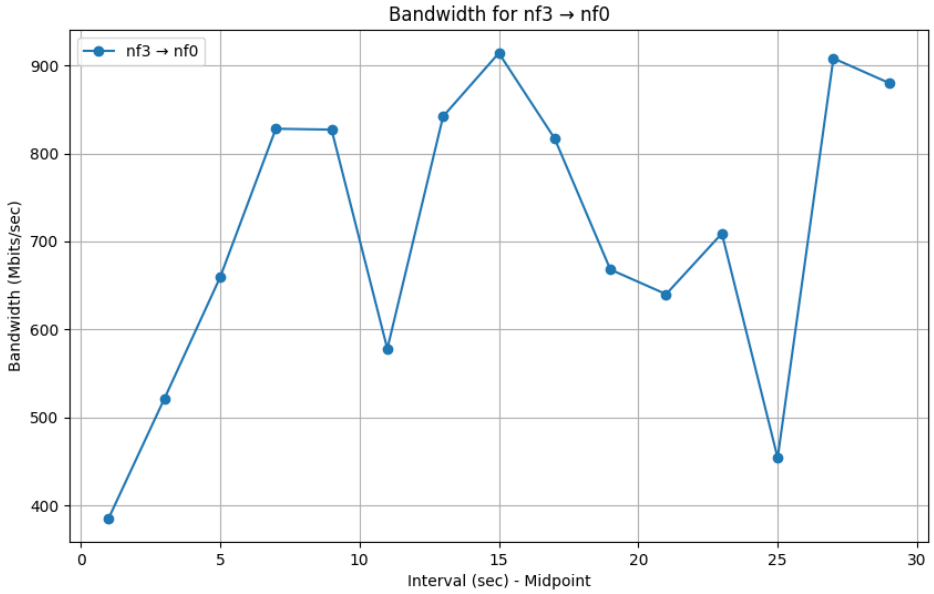

Fig.4.1.4 nf3->nf0

It looks like the same fluctuation trend as the NetFPGA being a network interface card, but let's look at the average and standard deviation of bandwidth.

Table 4.1 Average and Standard Deviation of Bandwidth Comparison between Router and NIC

Test	Router_Average Bandwidth(Mbits/sec)	Router_Standard Deviation(Mbits/sec)	NIC_Average Bandwidth(Mbits/sec)	NIC_Standard Deviation(Mbits/sec)
nf0->nf1	756.00	121.94	593.85	262.21
nf1->nf2	707.75	182.26	714.60	183.34
nf2->nf3	663.88	136.98	573.27	225.06
nf3->nf0	708.69	158.06	752.07	176.40

Average bandwidth of NetFPGA as Router across all tests: 709.25 Mbits/sec.
Average bandwidth of NetFPGA as NIC across all tests: 649.50 Mbits/sec.

From now on, we can know the bandwidth of NetFPGA as Router improves a lot compared with as NIC, since NetFPGA router can speed up IP forwarding and reduce CPU burden. Loading the routing table through rkd enables NetFPGA to know how to forward data packets.

2) Iperf test in UDP Mode for NetFPGA NIC
We did Iperf test in UDP mode for 5 times. The recorded bandwidth is as follows.

Table.4.2 Average Bandwidth for each Iperf Test

Test Times	Average Bandwidth(Mbits/sec)
1	181.87
2	140.77
3	182.65
4	172.00
5	221.25

Average bandwidth for 5 times tests: 179.71 Mbits/sec.

Using small packets stresses the system because it increases the number of packets per second that need to be processed, leading to higher CPU load, more interrupts, memory bottlenecks, and lower overall efficiency.

3) Iperf test in UDP Mode for NetFPGA Router

We did Iperf test in UDP mode for 5 times. The recorded bandwidth is as follows.

Table.4.2 Average Bandwidth for each Iperf Test

Test Times	Average Bandwidth(Mbits/sec)
1	182.17
2	209.25
3	243.50
4	236.25
5	231.25

Average bandwidth for 5 times tests: 220.48 Mbits/sec.

Questions:

1. What is the total bandwidth you are able to observe through the NetFPGA? Why does using small packets stress the system?

Answer:

1437.68 Mbits.

Possible causes:

- **Higher protocol overhead** (UDP & IP headers take up a larger percentage).
- **Increased CPU load** (more system calls and packet processing).
- **PPS limitations** (network devices cannot handle excessive small packets).
- **More packet loss and jitter** (UDP has no congestion control).
- **Fragmentation inefficiencies** (higher header-to-payload ratio).

2. Load the reference router.bit file again and start the rkd daemon. Run the same iperf test. What do you observe? Is it fair to say that the NetFPGA can route IP traffic bi-directionally at line speed for a total of 4Gbps of cross-wise bandwidth?

Answer:

The total bandwidth has increased. Hardware routing is more efficient than software-based forwarding, with lower latency and improved throughput.