Interconnection Networks for High-Performance Systems

ECE 6115 / CS 8803 – ICN

Spring 2022

Lab 2: Topology Comparison [55 pts]

Goal:

In this lab, you will evaluate and contrast the performance of a **Mesh (called Mesh_XY in Garnet)** against two topologies – (i) **Torus** and (ii) **HeterogeneousMesh** topology for network performance. The focus of this lab is on design space exploration – you will run a suite of simulations for of these three topologies and plot the results.

Step 0:

Update your gem5 copy from lab 1.

```
hg pull –u
```

If you are cloning a new copy, you do not need to perform this update.

Now build the simulator. This only needs to be done ONCE (the first time you pull).

```
./my_scripts/build_Garnet_standalone.sh
```

Sample Run Command:

```
./build/Garnet_standalone/gem5.opt
configs/example/garnet_synth_traffic.py \
--network=garnet2.0 \
--num-cpus=16 \
--num-dirs=16 \
--topology=Mesh_XY \
--mesh-rows=4 \
--sim-cycles=50000 \
--inj-vnet=0 \
--router-latency=2 \
--injectionrate=0.02 \
--synthetic=uniform_random \
--link-width-bits=32
```

The highlighted parameters are what you will be sweeping through in this Lab.

- All experiments will be with a 16-router (4 x 4 Mesh) system.
- **Unless otherwise mentioned, all your simulations should be for 50000 cycles.**

Traffic Description:

You will run three traffic patterns:

- Uniform Random (`--synthetic=uniform_random`)
- Bit Complement (`--synthetic=bit_complement`)
- Shuffle (`--synthetic=shuffle`)

The details of each traffic pattern can be seen in `src/cpu/testers/garnet_synthetic_traffic/GarnetSyntheticTraffic.cc`

How to run Traffic Simulations

Start at a (packet) injection rate of 0.02 and keep incrementing in intervals of 0.02 *till the network saturates (i.e., the latency becomes > 100 cycles).* In other words, you do not need to run it till a fixed injection rate (like 0.5 in Lab 1) but till the injection rate at which that network saturates. **This is because you will cut off the y-axis off at 100 cycles.**

Network Stats:

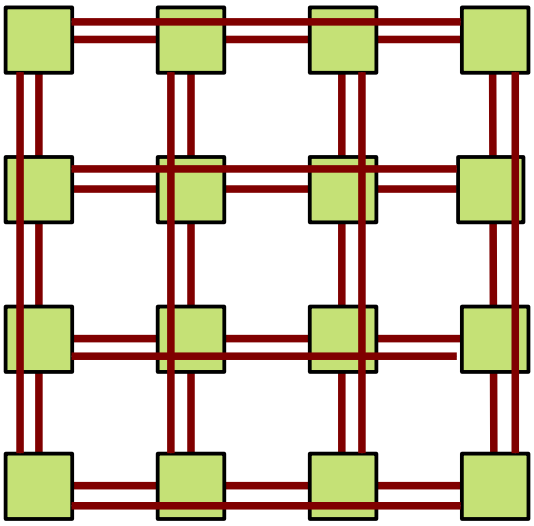
`./my_scripts/extract_network_stats.sh` generates `network_stats.txt`.
You will be working with *average_packet_latency* and *packets_received* as the stats for this lab.

How to Plot Results

For each <traffic pattern, configuration> pair, you need to plot the ***average packet latency vs. injection rate*** for all three topologies on the *same* graph. In other words, each graph in your report will have 3 lines: Mesh, Torus and HeterogeneousMesh. The configurations will be discussed in Step 3.

Note: average packet latency is in cycles.
Make sure to label the axes, and add clear legends to specify which line corresponds to which topology.

Step 1: Torus (10 points)

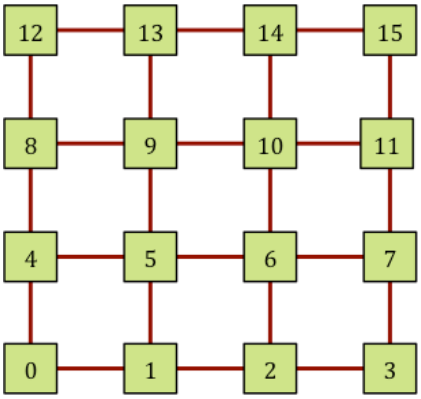


Step 1.1
Create a `Torus.py` file in `$gem5/configs/topologies`

It is a python file. But you do not need to be a python expert to write this.

Tips: Take a look at Mesh_XY.py for reference.

- Mesh_XY.py has some print commands to print all the links that are created every time a simulation is run – this will be useful for debugging.
- All links are uni-directional – i.e., **you need to add links in both directions**.
- You will notice a link weight of "1" on the x-links and "2" on the y-links. This is for deadlock avoidance which we will talk about later. Please use the same allocation in the topologies you implement.
- Reuse the **mesh-rows** parameter that Mesh_XY.py uses to specify the number of rows in the Torus topology.
- The router ids used in Mesh_XY code follow the following numbering scheme (0 to 15):
-

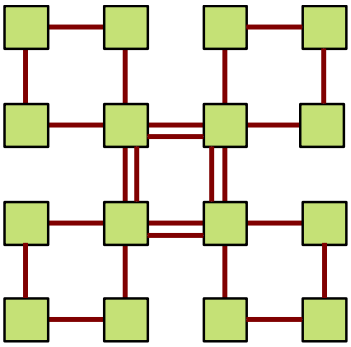


- *Note – for simplicity, you can assume that this topology will only be called with 16 routers and add links; accordingly, you do not need to make it generic.*

Step 1.3

You can run this topology by specifying `--topology=Torus`
Test your topology using the run command. You can also use the debugging tips on the garnet GT website: http://tusharkrishna.ece.gatech.edu/teaching/garnet_gt/ to make sure the latency and hop values make sense with this topology.

Step 2: Heterogeneous Mesh (10 points)



Create a `HeterogeneousMesh.py` file in `$gem5/configs/topologies`
See instructions in Step 1.

Step 3: Performance Simulations and Plots [10 pts]

Configuration A: Equal Link Widths

Suppose there are no wire constraints.
Assume that all topologies have the same link width: **32b**.

Step 3.A.1: For each topology – Mesh_XY, Torus and HeterogeneousMesh, plot the average packet latency vs injection rate across all three traffic patterns. [Look at "How to Plot Results" above].

Step 3.A.2: Add these three graphs into a document called Report. Label each graph clearly (4 points)

Configuration B: Equal Bisection Bandwidth.

Suppose that all three topologies have the same ***bisection bandwidth*** **in terms of wire area**.

Assume that the **Mesh has 32b links**.
Scale the link widths in Torus and HeterogeneousMesh accordingly.

In your report add the links widths in each topology. [1 pt]

Mesh:	32b
Torus:	
Heterogeneous Mesh:	

Recall the network latency equation. Which component of the total network latency does the link width affect? [1 pt]

Step 3.B.1: For each topology – Mesh_XY, Torus and HeterogeneousMesh, plot the average packet latency vs injection rate across all three traffic patterns. [Look at "How to Plot Results" above].

Step 3.B.2: Add these three graphs into a document called Report. Label each graph clearly (4 points)

Step 4: Analysis Questions [20 pts]

Complete Lab2-Questions.docx.

What to Submit:

Create a tarball called Lab2.tar.gz with the following files:
Torus.py **HeterogeneousMesh.py**
Report.doc/pdf **Lab2-Questions.doc/pdf**