Due by: BY THE END OF YOUR CLASS

CSE443/543: High Performance Computing

Exercise #20: HPC Interconnects

Points: 20

Submission Instructions

Objective: The objective of this exercise is to:

- Gain familiarity with HPC interconnects.

Submission: Upload the following at the end of the lab exercise via Canvas CODE plugin:

1. This MS-Word document saved as a PDF file with the convention `MUID_Exercise20.pdf`.

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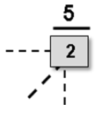
1. Illustrate the output from the following program (compiled to a file called `gather`) when it is executed using the command line(s) shown further below.

```
#include <iostream>
#include <boost/mpi.hpp>
namespace mpi = boost::mpi;

int main(int argc, char *argv[]) {
   mpi::environment env(argc, argv);
   mpi::communicator world;
   int rank = world.rank();

   rank %= 3;  // Ensure rank is valid
   std::string src  = "123456";
   std::string dest = src;
   // Gather a character from each process to dest at rank 0
   mpi::gather(world, src[rank], &dest[0], 0);

   if (rank == 0) {
       std::cout << "Result = " << src << ", " <<  dest << std::endl;
   }
}
```

```
$ mpiexec -n 6 ./gather 1 2 3 4 5 6
```

Illustrate the **optimal** sequence of operations that MPI would perform on a hypercube by tracing the sequence of communication operations along each dimension in the appropriate order. At each phase: ➔ Draw directed arrows between nodes to indicate flow of data. ➔ Fill in the intermediate value(s) that would be present at each of the processes as the operations proceed. For example, if a process with rank 2 has an value of 5, then this would be represented as shown in the adjacent figure.



Trace the three phases of ***optimal*** communication operations along each dimension in the hypercube figures shown below

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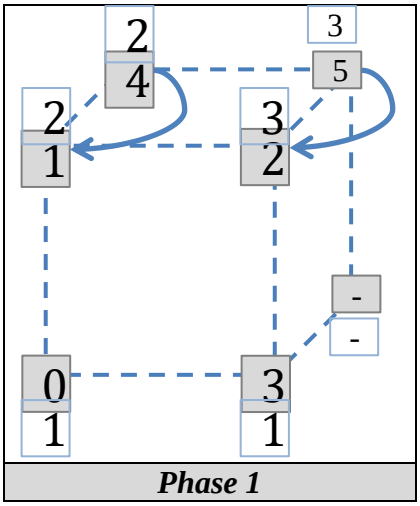
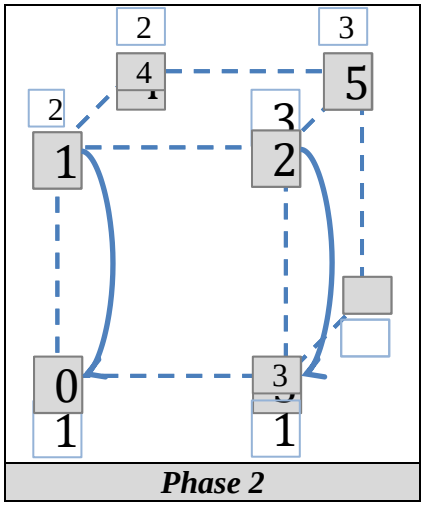
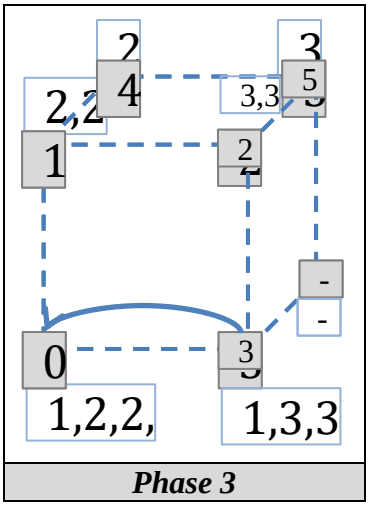


Phase 1



Phase 2



Phase 3

The output from the program is:

Results = 123456. 123456
Results 123456,123123

2. The following table (namely, Table 1) illustrates the salient characteristics of three different interconnect topologies that are being proposed for a supercomputing cluster. All the topologies use exactly the same hardware/technology. Consequently, the speed and bandwidth of each link in all three networks is identical.

Network Name	*Diameter*	*Bisection Width*	*Connectivity*	*Cost*
Net-α	3	4	7	200
Net-β	2	5	5	150
Net-δ	5	2	3	100

Table 1: Salient characteristics of three different interconnect technologies.

i. Given the interconnects in Table 1, if a supercomputing cluster design aims to have an interconnect topology that would have the lowest average latency, the best choice of topology would be:

A. Net-α

B. Net-β

C. Net-δ

D. Any one of the above

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ii. Given the interconnects in Table 1, if a supercomputing cluster design aims to have an interconnect topology that permits large volumes of data to be rapidly exchanged between compute nodes, the best choice of topology would be:

A. Net-α

B. Net-β

C. Net-δ

D. Any one of the above

iii. Given the interconnects in Table 1, if a supercomputing cluster design aims to have an easily reconfigurable interconnect topology, the best choice of topology would be:

A. Net-α

B. Net-β

C. Net-δ

D. Any one of the above

3. Clearly circle only the best response for each question below:

i. The architecture of a single compute node shown in the adjacent figure falls under the cateogry of

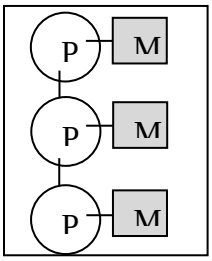
A. UMA

B. Distributed memory architecture

C. NUMA.

D. PUMA.

Legend: P - Processor M - Memory



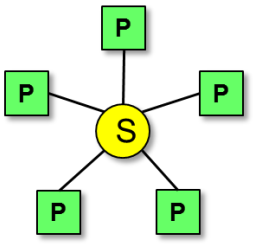
ii. The diameter of the interconnect topology shown in the figure below is:

A. 1

B. 2

C. 3

D. 4



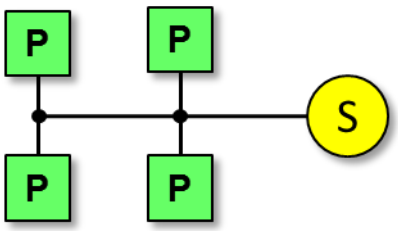
iii. The interconnect topology shown in the figure below is:

A. A bus

B. A crossbar

C. A 2-D hypercube

D. A 2-D Torus



iv. The interconnect that is ideal for broadcasting would be:

A. A bus

B. A crossbar

C. A 2-D hypercube

D. A 2-D Torus

v. Given 32 devices, the minimum number of stages needed in an omega network to interconnect these devices would be:

A. 3

B. 4

C. 5

D. 6

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1. This MS-Word document saved as a PDF file and named with the convention *MUid_Exercise20*.pdf.