High-Performance Computing Networks at BYU

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Physics generally limits us on the faster resources, so we spend more time on parallelism.

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  - Remote Direct Memory Access (RDMA)

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LID Logical Identifier (address) assigned by the subnet manager to the HCA; kinda like an IP, but resides in the upper part of layer 2

SM Subnet Manager, a hardware or software device that assigns LIDs to GUIDs, and pre-loads the switch forwarding tables

Lanes/Links/Speeds

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	SDR	*DDR*	*QDR*	*FDR*
1x	2.5 Gb/s	5 Gb/s	10 Gb/s	14 Gb/s
4x	10 Gb/s	20 Gb/s	40 Gb/s	56 Gb/s
12x	30 Gb/s	60 Gb/s	120 Gb/s	168 Gb/s

Encoding Overhead

Infiniband uses bit-line encodings to guarantee bit transitions for clock synchronization:

- SDR, DDR, QDR - 8b/10b encoding (8 data bytes encoded in 10 bytes total; 20% overhead)
- FDR and beyond - 64b/66b encoding (64 data bytes encoded in 66 bytes total; 3% overhead)

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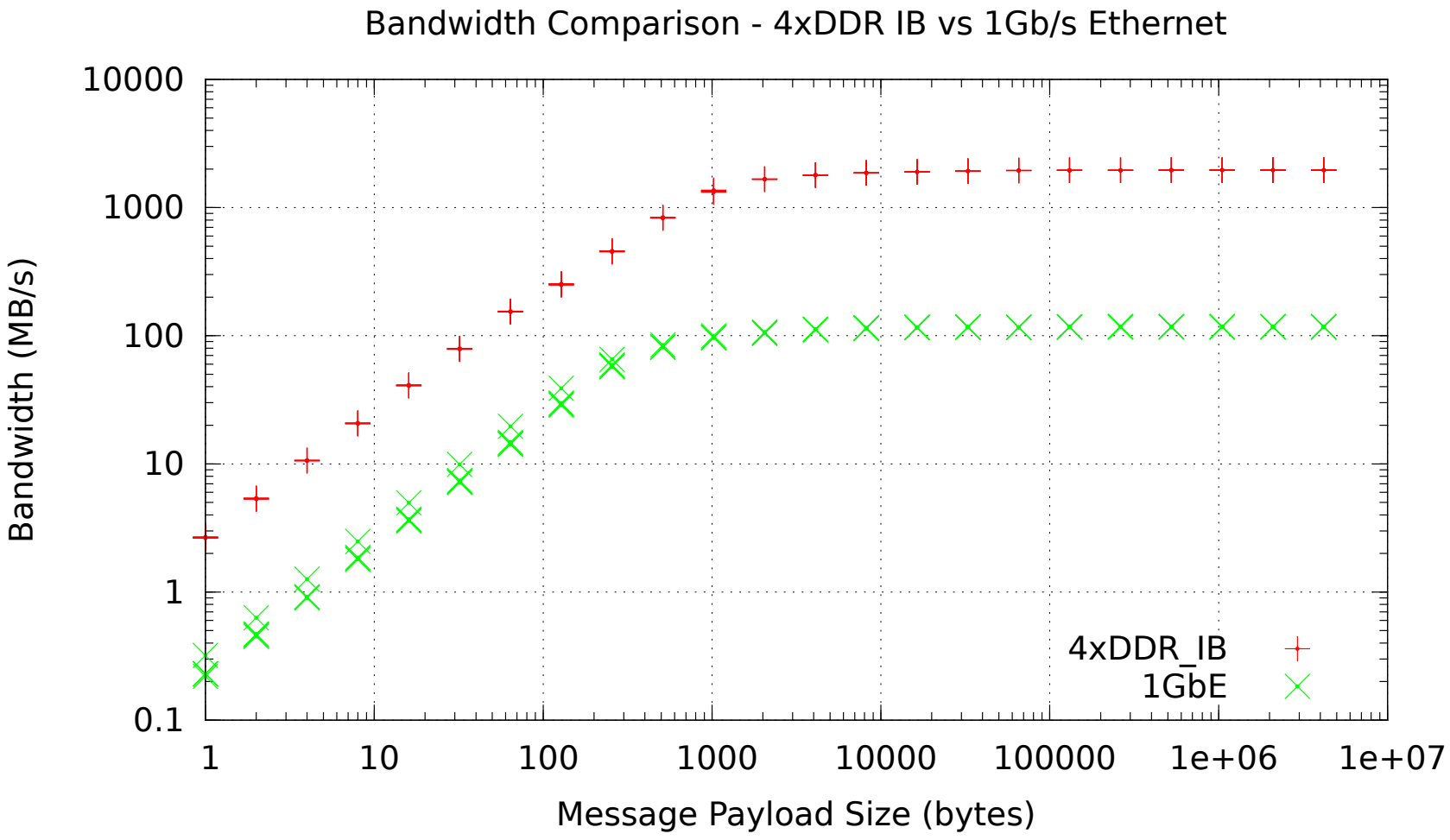
4x	10 Gb/s raw 8 Gb/s net	20 Gb/s raw 16 Gb/s net	40 Gb/s raw 32 Gb/s net	56 Gb/s raw 54.3 Gb/s net
12x	30 Gb/s raw 24 Gb/s net	60 Gb/s raw 48 Gb/s net	120 Gb/s raw 96 Gb/s net	168 Gb/s raw 162.9 Gb/s net

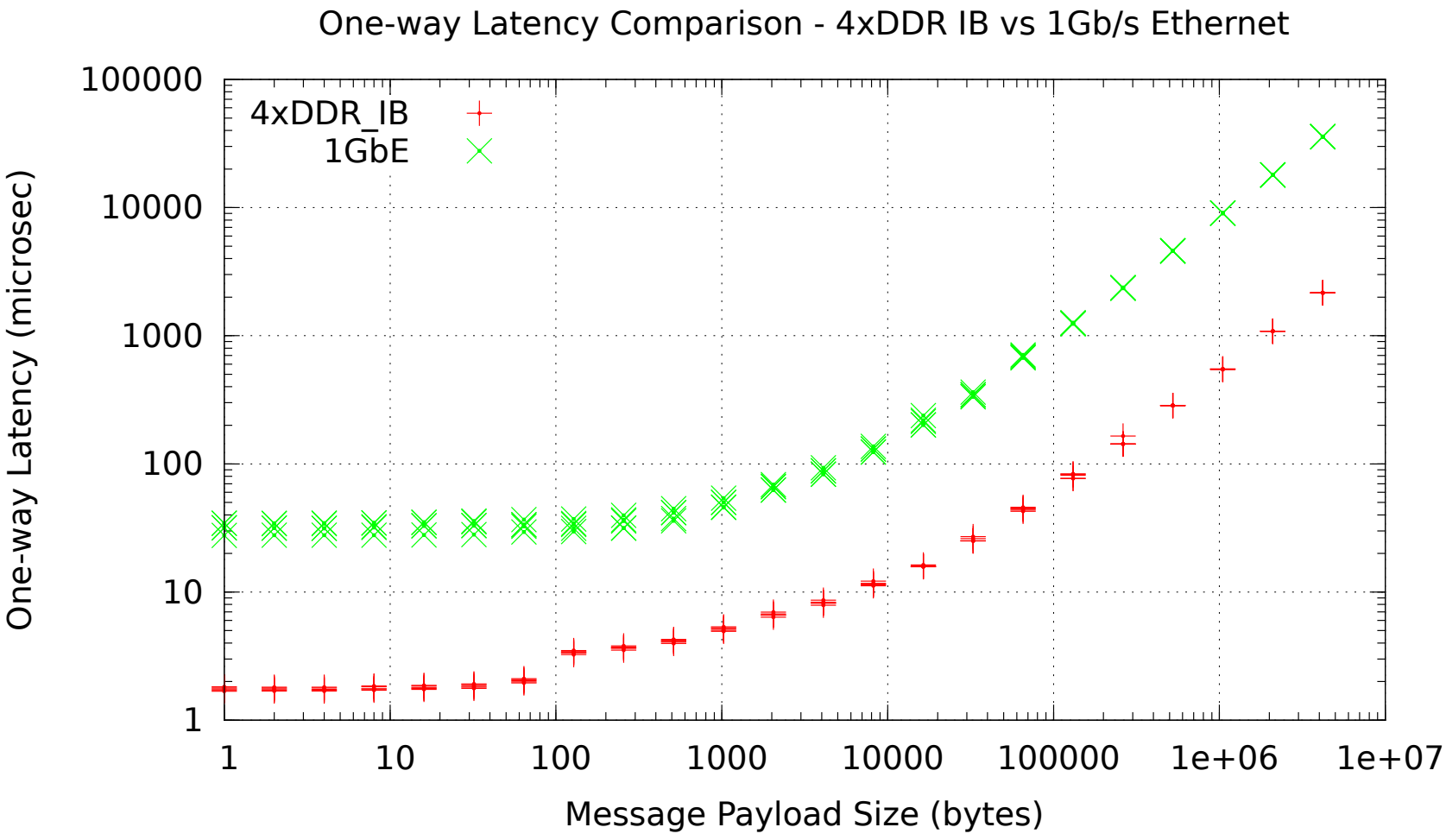
Performance at BYU's FSL

The graphs shown in the next couple of slides represent the bandwidth and latency performance of 4xDDR Infiniband vs 1Gb/s Ethernet at the Fulton Supercomputing Lab.

- All tests were performed host-to-host with one intervening switch (eg. host-switch-host)
- All tests utilize increasing message sizes, to demonstrate where one effect ends and the other starts
- Tests were performed using the "osu_bw" and "osu_latency" binaries from the OSU Micro-Benchmarks for MPI (a.k.a. "OMB")[1]

[1] http://mvapich.cse.ohio-state.edu/benchmarks/


Bandwidth Comparison - 4xDDR IB vs 1Gb/s Ethernet
Bandwidth (MB/s)
10000
1000
100
10
1
0.1
1
10
100
1000
10000
100000
1e+06
1e+07
Message Payload Size (bytes)
4xDDR_IB
1GbE


One-way Latency Comparison - 4xDDR IB vs 1Gb/s Ethernet
4xDDR_IB
1GbE
One-way Latency (microsec)
Message Payload Size (bytes)
100000
10000
1000
100
10
1
1
10
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1000
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- Build a cohesive model of the network topology
- Load the switch forwarding tables with the LID/Port mapping

Infiniband Topologies

Infinband puts very little restriction on the physical topology of the network.

[2] Technically you can use any topology with Ethernet as well. It just takes a huge amount of very-messy work, for very little benefit. I don't recommend trying it.

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  - allows some much more interesting topologies than those commonly Ethernet and TCP/IP networks usually use.[2]

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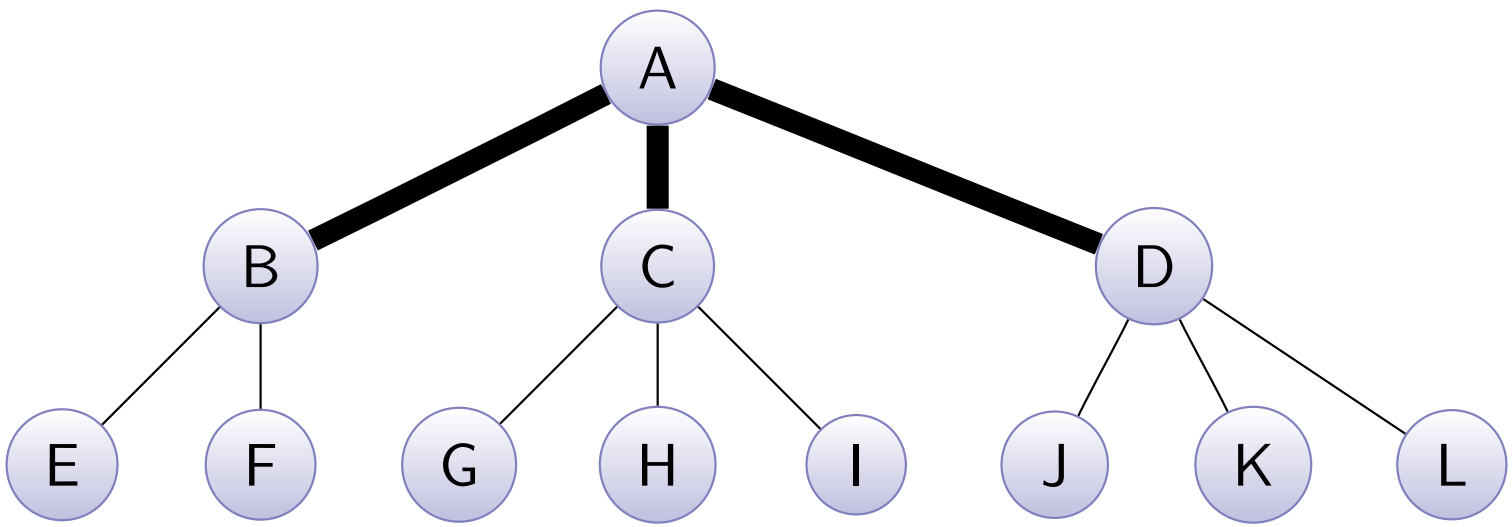
- Folded-Clos Network

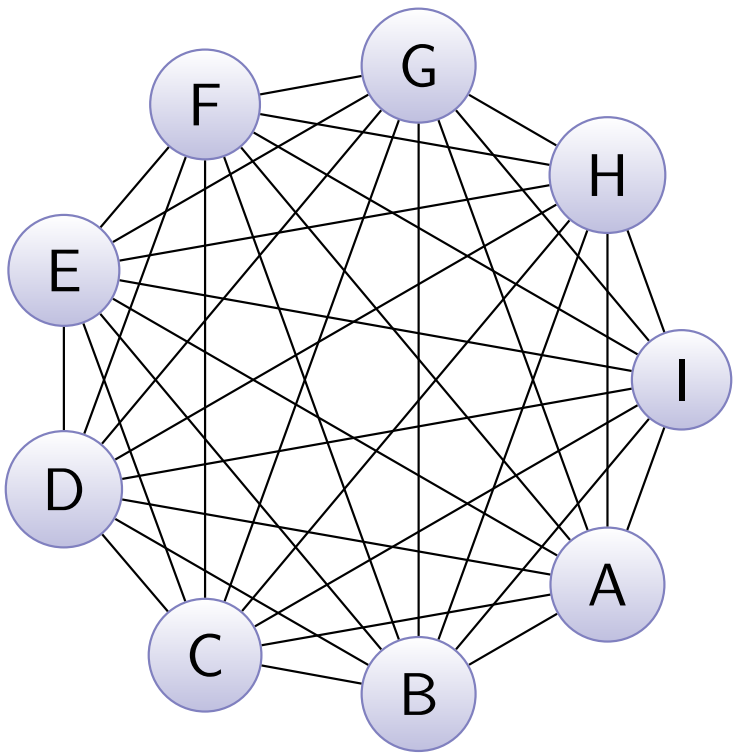
Fat Tree Example

A *Fat Tree* is basically a tree with increased bandwidth (faster links or more links) between upper tiers relative to lower tiers; Ethernet has no problems with this one, so it's not terribly exciting



Fully-connected Mesh Example

- Pro: Shortest hop-count (1 hop) from any point to any other point



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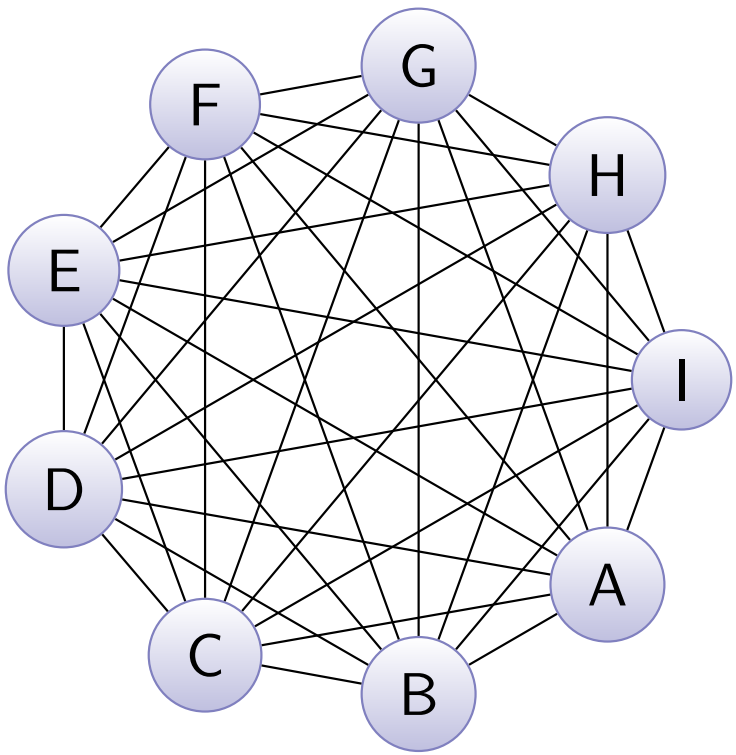
- Con: takes a huge amount of cables, and the cable count increases very, very quickly.



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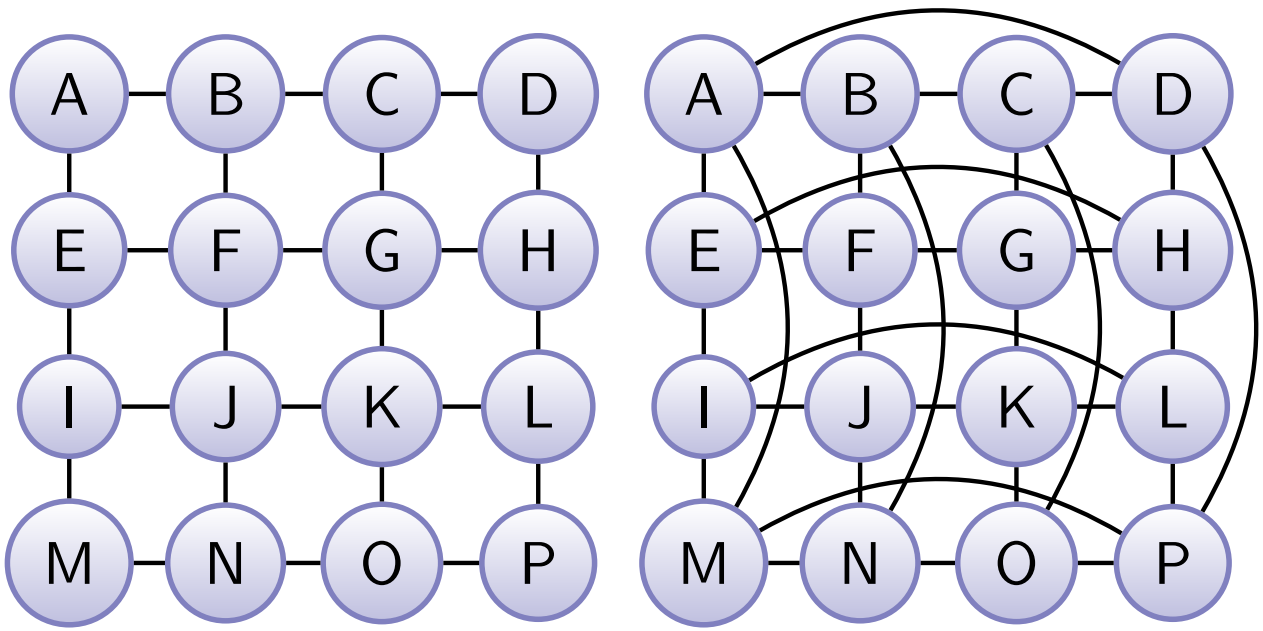

(a) Rectangular (b) Toroidal

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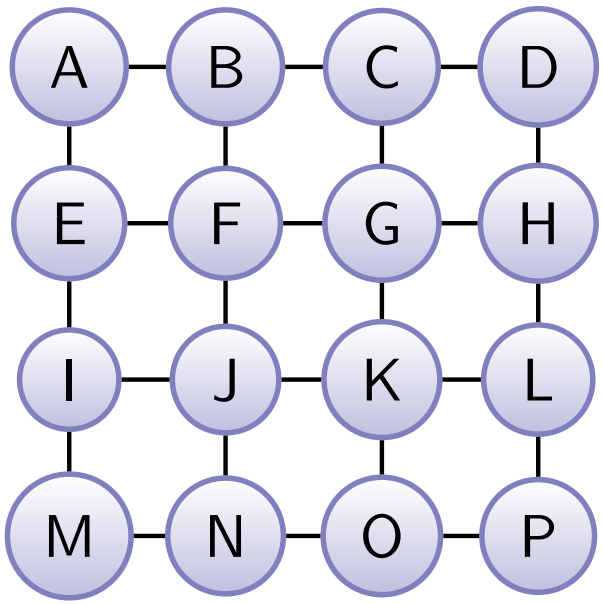
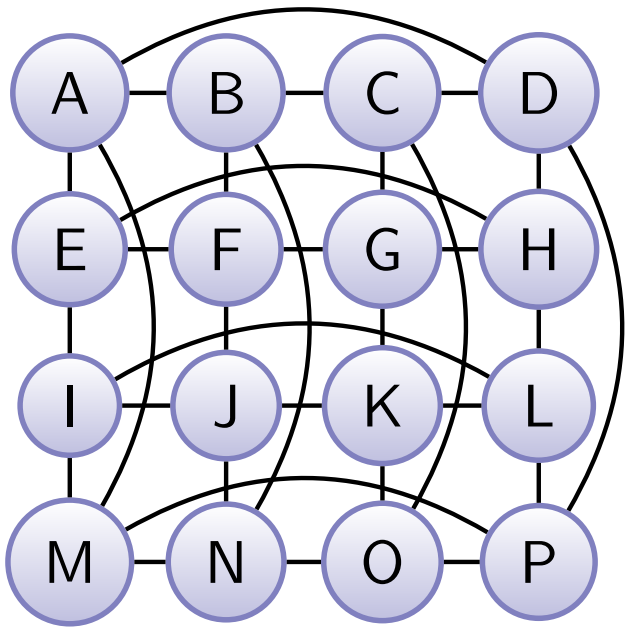


(c) Rectangular



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Hypercube example (4-d)

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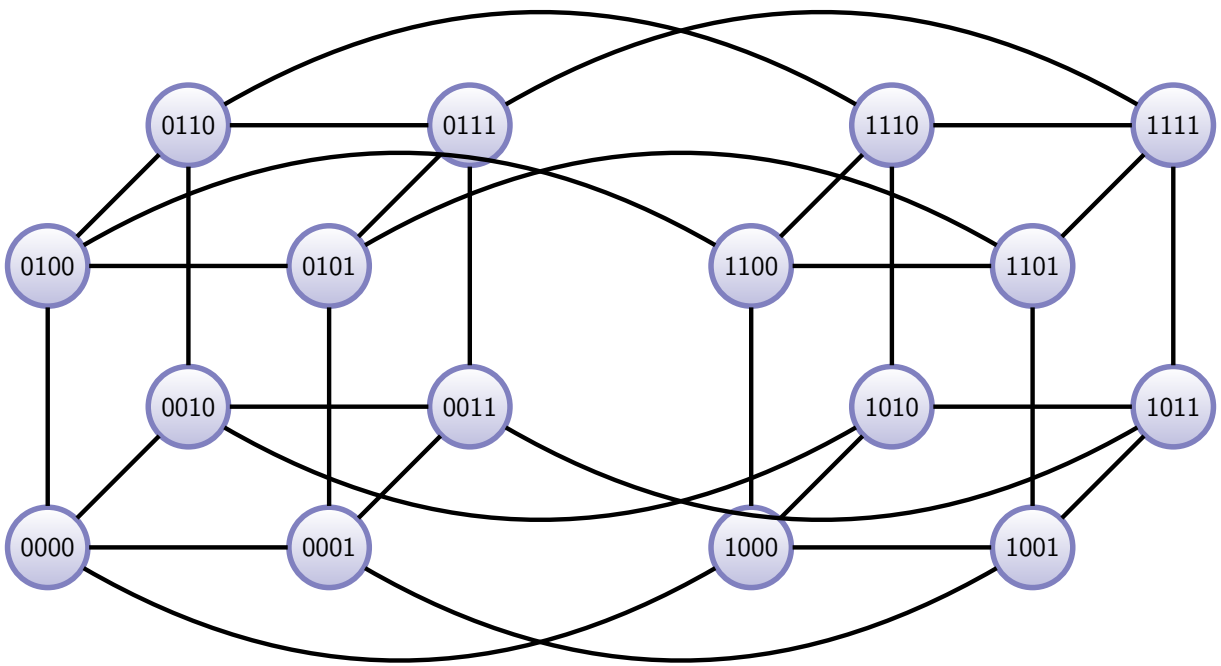

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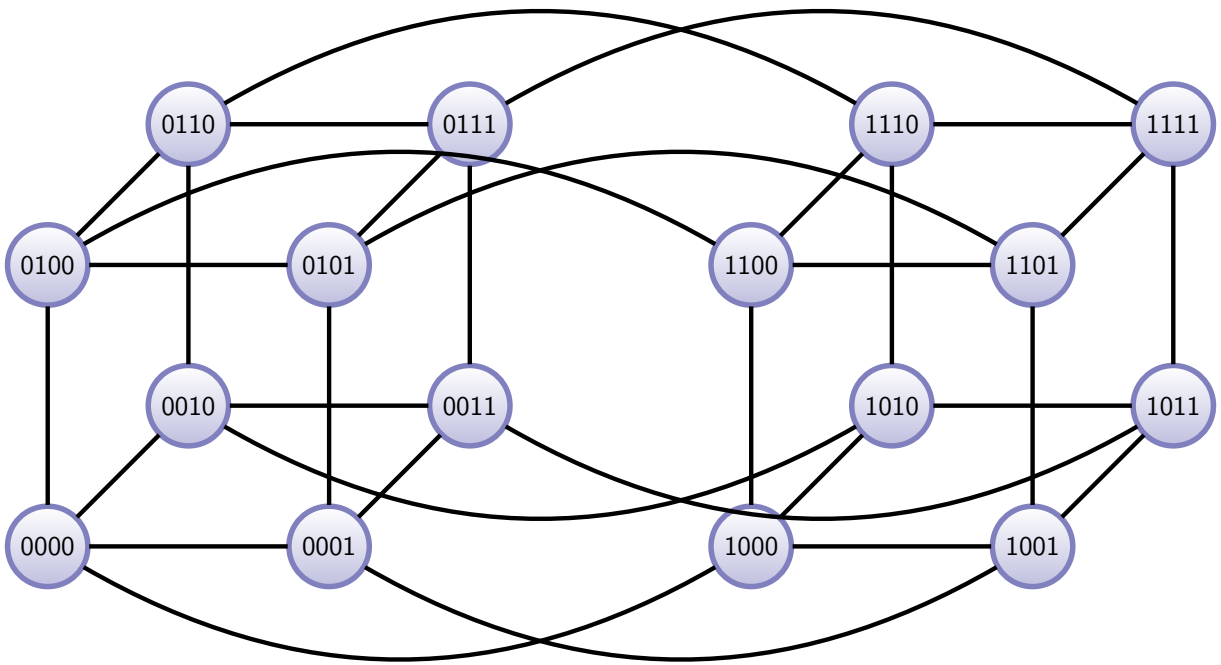

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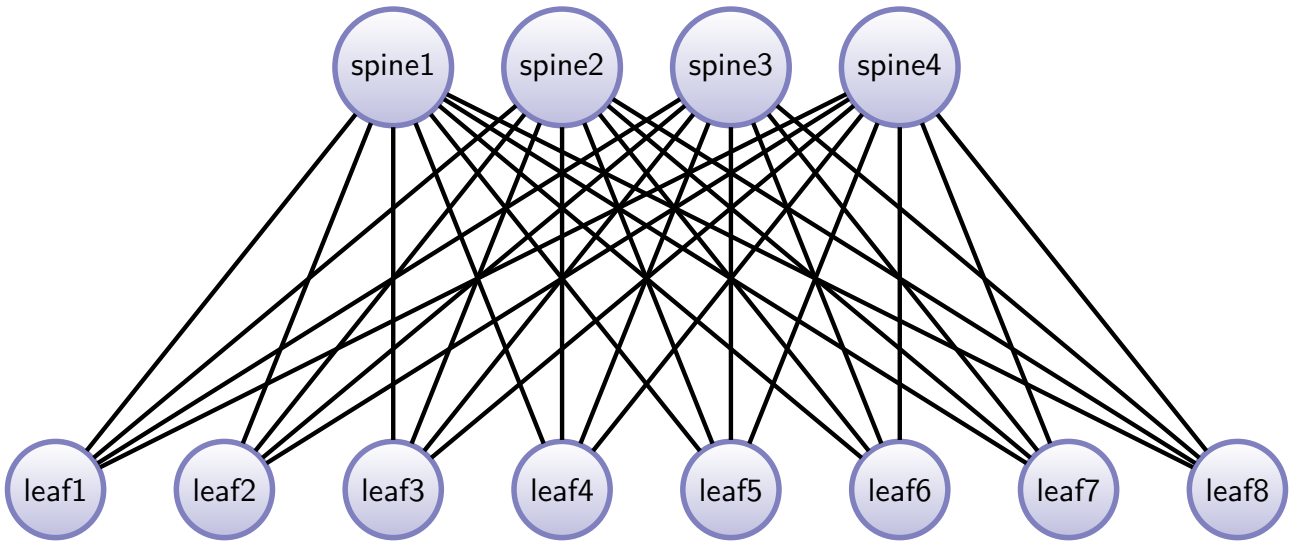
  - Most common approach for small or medium-scale Infiniband fabrics



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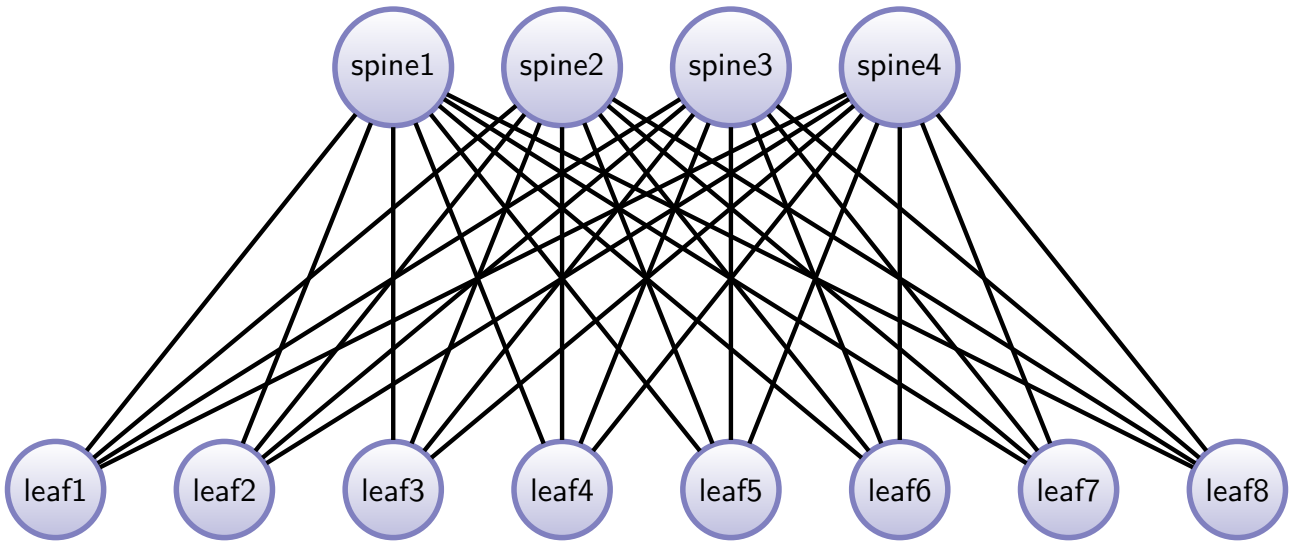

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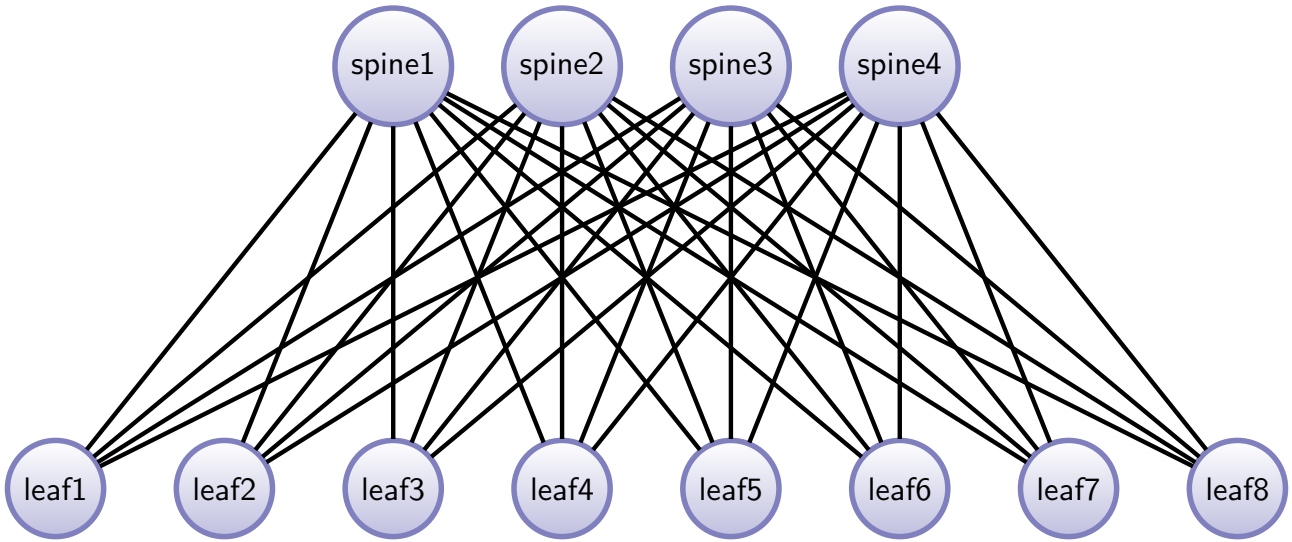

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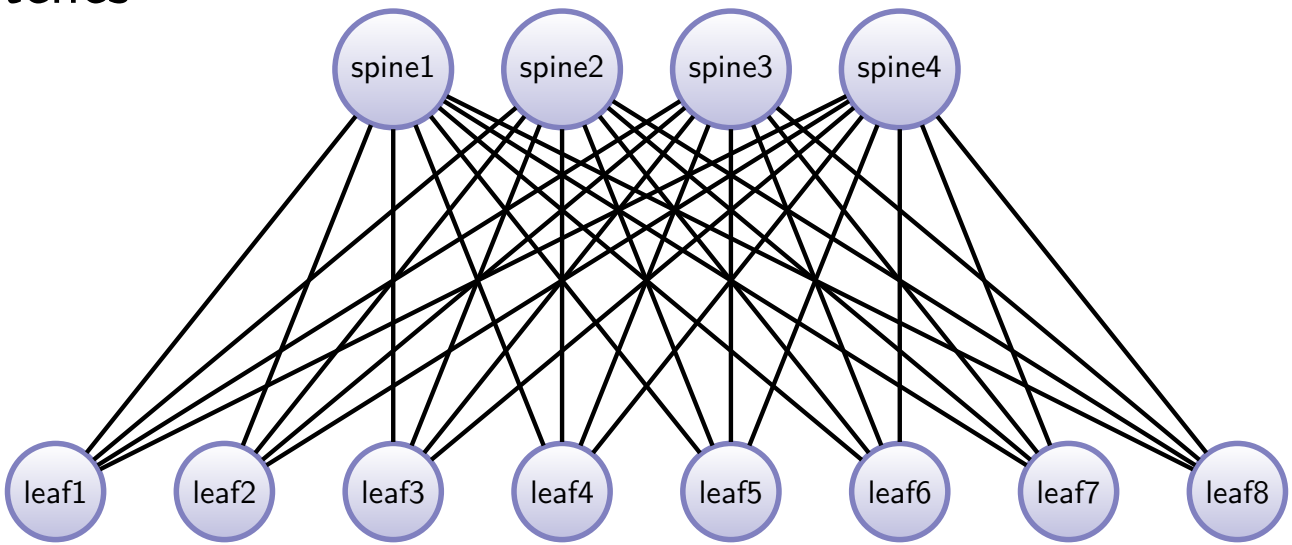
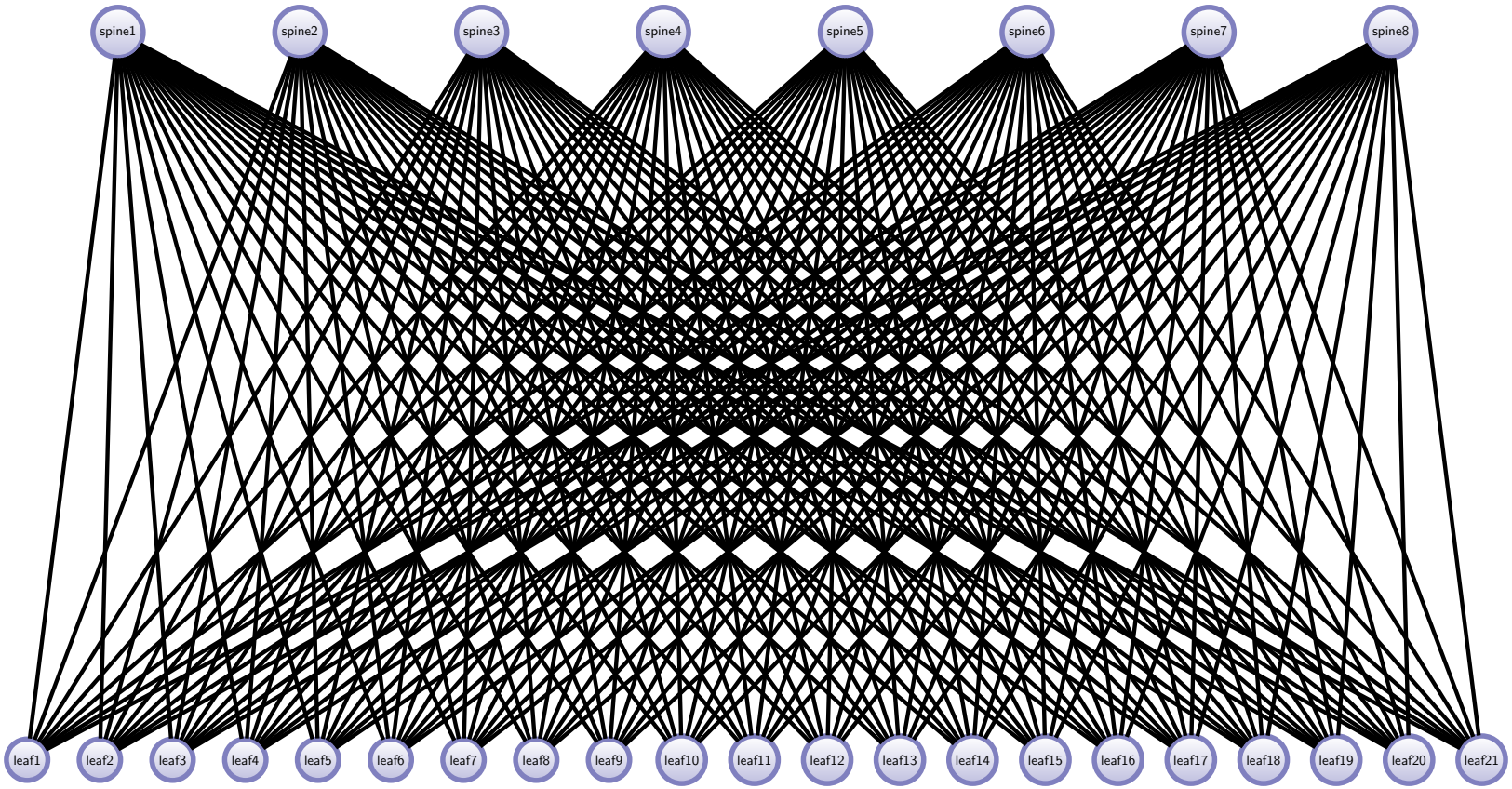


BYU Supercomputing's Clos Network



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- **SDP** Sockets Direct Protocol - basically sockets protocol for IB

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FlexBoot PXE-like network booting

Message Passing

- In HPC, most applications use a message-passing library like MPI, which in turn uses the Verbs API to do its work.
- Several dozen MPI implementations exist, but the most common that can utilize Infiniband are:
  - OpenMPI
  - MVAPICH
  - Intel MPI
  - HP/Platform MPI

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- Per-port cost for 4xQDR Infiniband (40 Gb/s) is usually less than 10-Gigabit Ethernet, but this changes over time
- 4xQDR (40Gb/s) HCAs can be repurposed (via firmware change) to be 10-Gigabit Ethernet NICs

Questions?

Any questions?