Network Topologies

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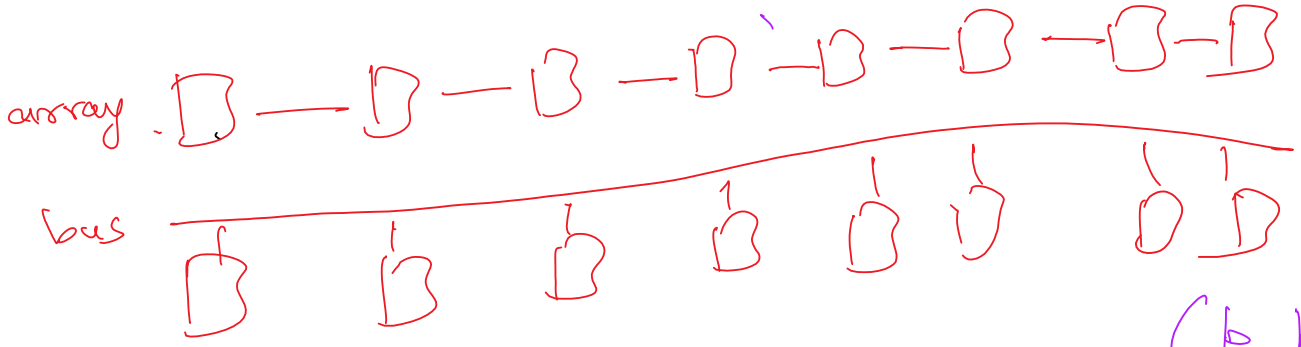
Array / bus Topology:



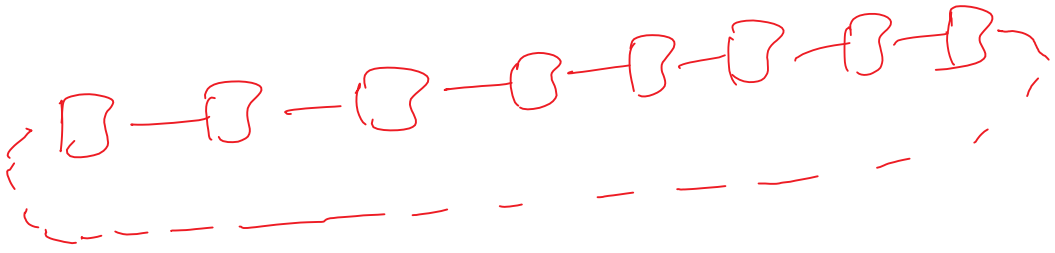
(p nodes)

diameter = p - 1 (terrible!)

bisection bandwidth = 1 (terrible!)

links / node = 2 (great!)

Ring topology:



diameter ≈ p/2 ✓ (still terrible!)

Bisec. bw = 2

links per node = 2

Mesh

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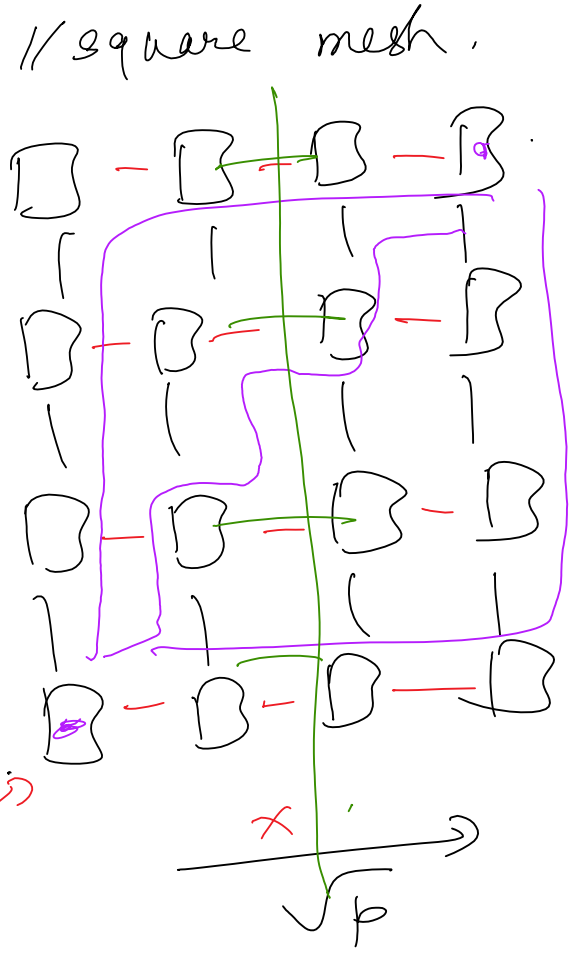
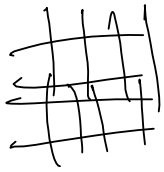
3) Mesh Topology:

// square mesh.





diameter:

$(\sqrt{p}-1) \times 2$

Bisec. band.

$\sqrt{p}$

links per node = 4

$p^{1/2} \Rightarrow p^{1/d}$

extension to arbitrary dimensions

Torus

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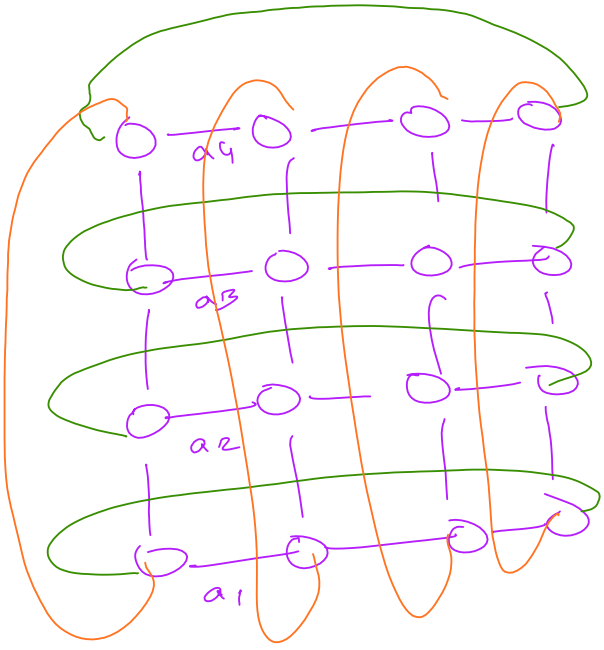
TORUS

⇒ A wrap-around mesh

2D torus ⇒



The IBM BlueGene/Q supercomputer is an example in real-word which has a 5-D Torus.

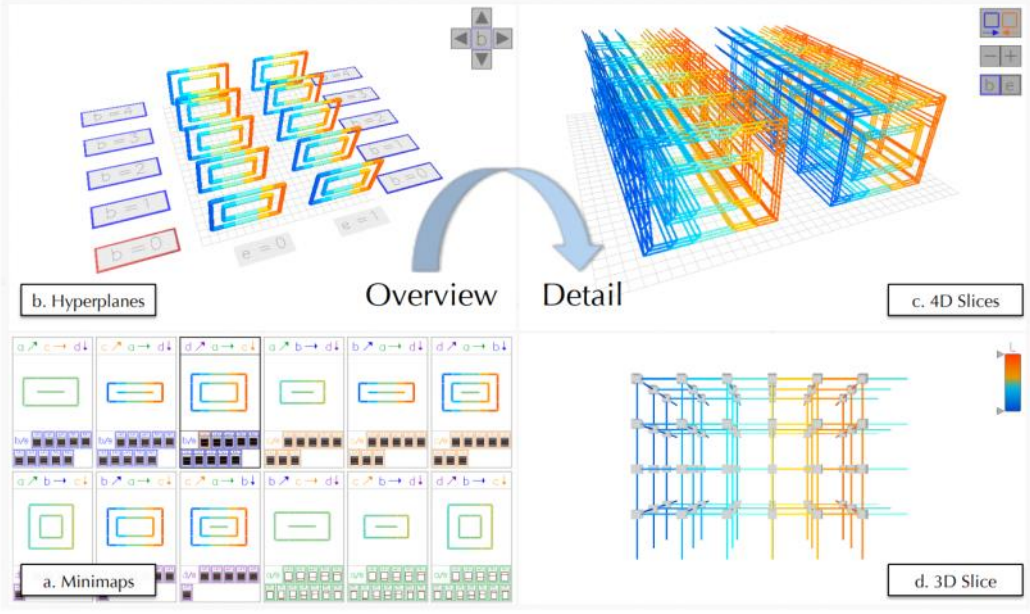


Fig. 1: Visualization of IBM Blue Gene/Q Five-dimensional torus interconnection network using four linked views.

Picture courtesy of:

McCarthy, Collin M., Katherine E. Isaacs, Abhinav Bhatele, Peer-Timo Bremer, and Bernd Hamann. "Visualizing the five-dimensional torus network of the IBM Blue Gene/Q." In *Proceedings of the First Workshop on Visual Performance Analysis*, pp. 24-27. IEEE Press, 2014.

Hypercube

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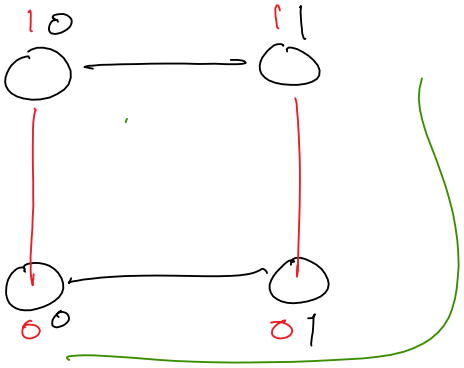
4) Hypercube Topology: (p: processors = nodes) $\Rightarrow 2^d$

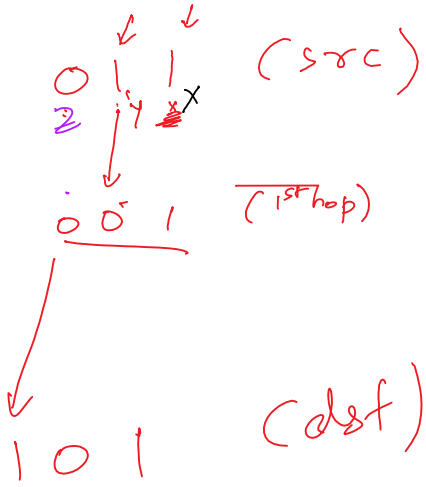
Let d: # dimensions.

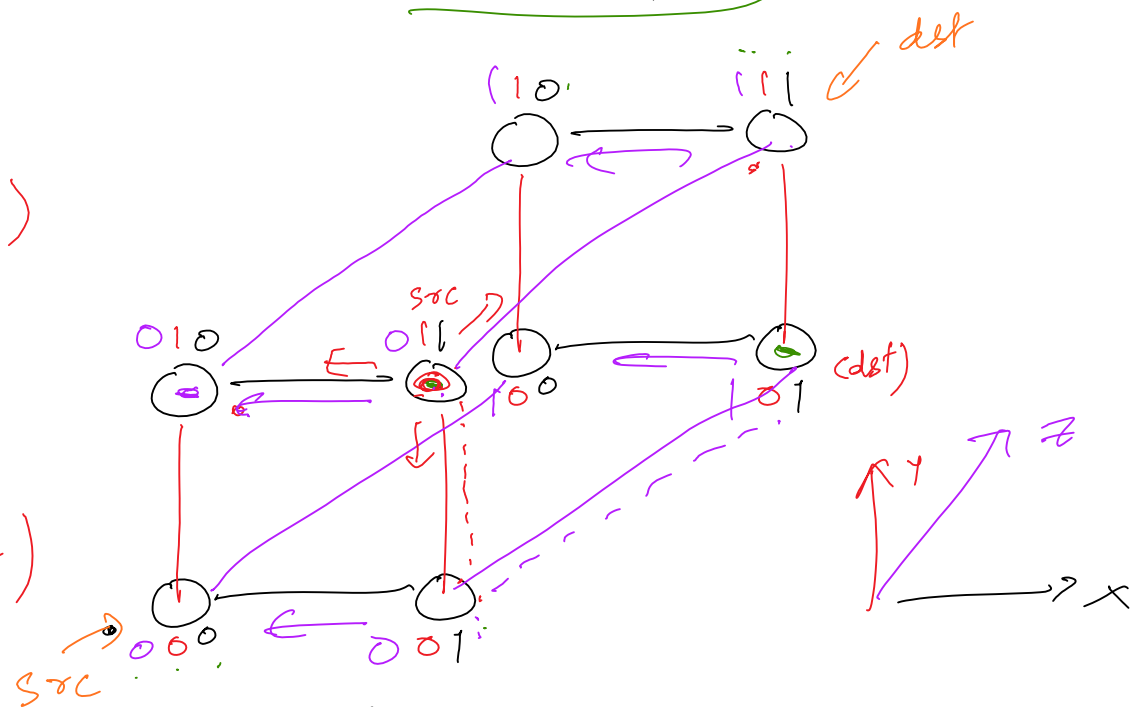
d = 1

d = 2



d = 3

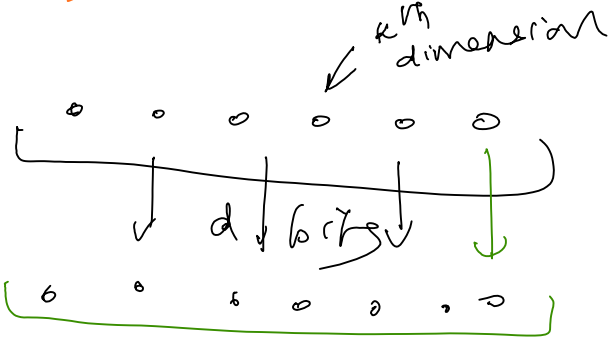




process rank:

(src)

(dst)



How many procs = 2^d

Hypercube:

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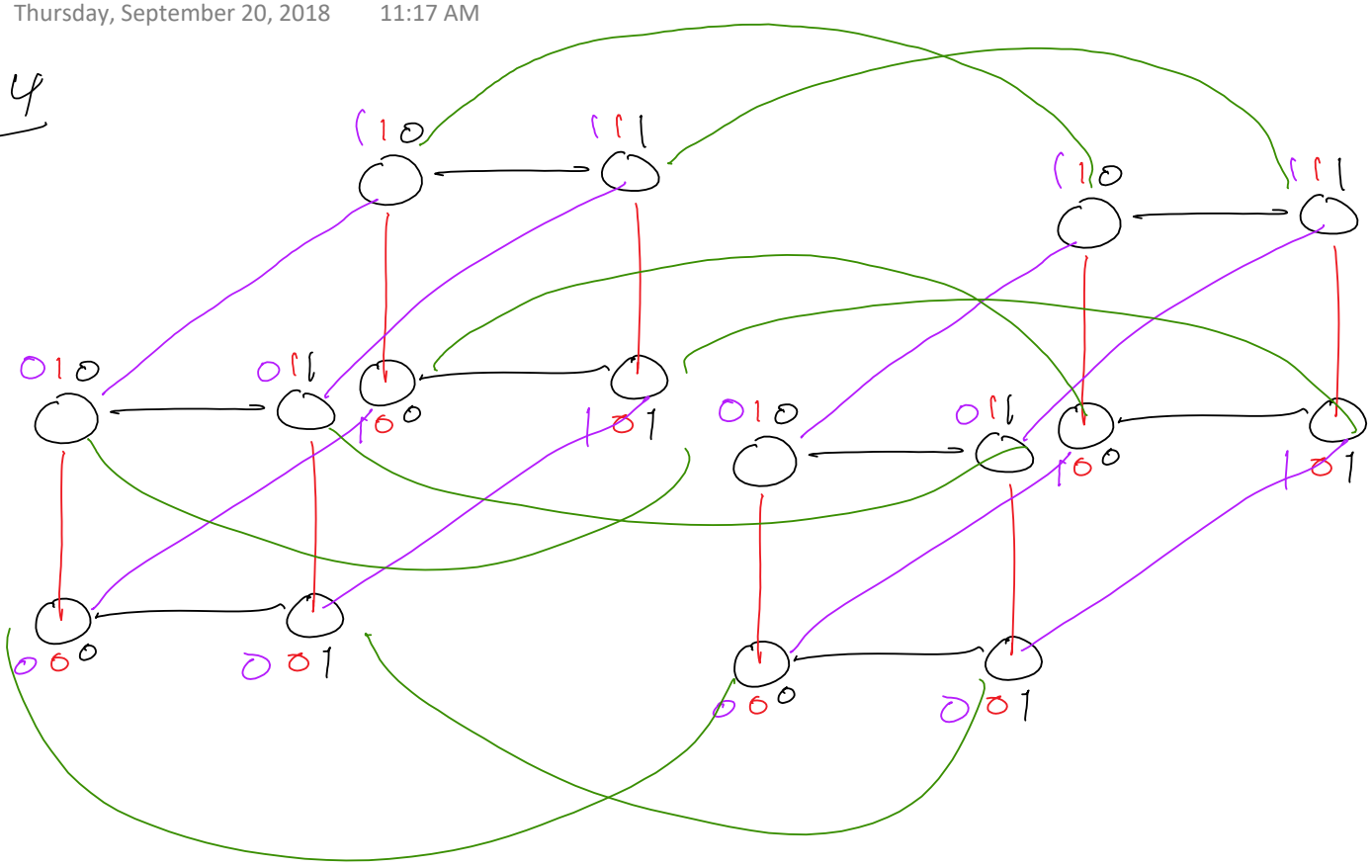
$d = 4$



Basic prop:

1) #procs (p) $= 2^d = 2^{d-1} + 2^{d-1}$

2) Diameter $= d = \lg_2 p$ ✓

3) Links per node $= d = \lg p$ ✗

4) Bisec. B/W $= 2^{d-1} = \frac{1}{2} p$ ✓

(PN $= \min\{C, \lg p\}$ (real world) → 4 or 5

Hybercubic permutation

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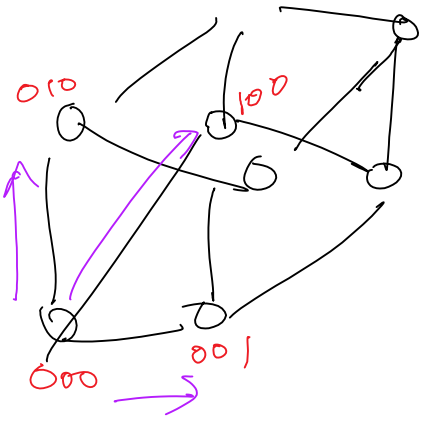
Example where a hypercubic permutation could help write "good" parallel programs!

E.g. Reduce (operator)



i ← my proc. rank

p ← # procs.

Reduce ( )

Init local-result

for (t = 0 to (lg p - 1))

j ← toggle the t^{th} least significant bit in the binary representation of i

communicate with proc. rank j