## Initials: Solutions

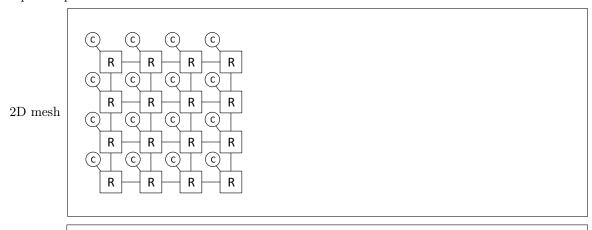
## 5 Interconnection Networks [90 points]

Suppose you would like to connect  $2^N$  processors, and you are considering four different topologies:

- $\sqrt{2^N} \times \sqrt{2^N}$  2D mesh
- $\sqrt{2^{N-2}} \times \sqrt{2^{N-2}}$  2D concentrated mesh (Cmesh), where each router serves four processors
- $\sqrt{2^N} \times \sqrt{2^N}$  2D torus
- Hypercube

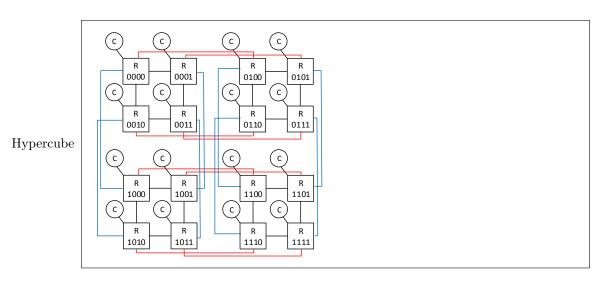
Please answer the following questions. Show your work.

(a) [20 points] For N = 4, please draw how each network looks like. You can use ... (three dots) to avoid repeated patterns.



Cmesh

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For the remaining questions, assume N = 8.

(b) [20 points] For N = 8, calculate the number of network links for each network. (Hint: a single network link is bi-directional)

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2D mesh: 2 \times (\sqrt{2^N} - 1)(\sqrt{2^N}) links \to 2 \times 15 \times 16 = 480 links Cmesh: 2 \times (\sqrt{2^{N-2}} - 1)(\sqrt{2^{N-2}}) links \to 2 \times 7 \times 8 = 112 links 2D torus: 2 \times (\sqrt{2^N})(\sqrt{2^N}) links \to 2 \times 16 \times 16 = 512 links Hypercube: 2^N \times N/2 links \to 256 \times 8/2 = 1024 links
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(c) [25 points] For N = 8, calculate the number of input/output ports including the injection/ejection ports for *each router* in these topologies (Hint: give answer to all types of routers that exist in an irregular network).

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2D mesh: (4+1) inputs/outputs, (3+1) inputs/outputs, and (2+1) inputs/outputs Cmesh: (4+4) inputs/outputs, (3+4) inputs/outputs, and (2+4) inputs/outputs 2D torus: (4+1) inputs/outputs Hypercube: N+1 inputs/outputs \rightarrow 9 inputs/outputs
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(d) [25 points] Assume a network link can be faulty. For each topology, what is the minimum possible number of faulty links that are needed to make at least one processor unreachable from any other processor?

2D mesh: 2 links Cmesh: 2 links 2D torus: 4 links

Hypercube:  $Nlinks \rightarrow 8$  links

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