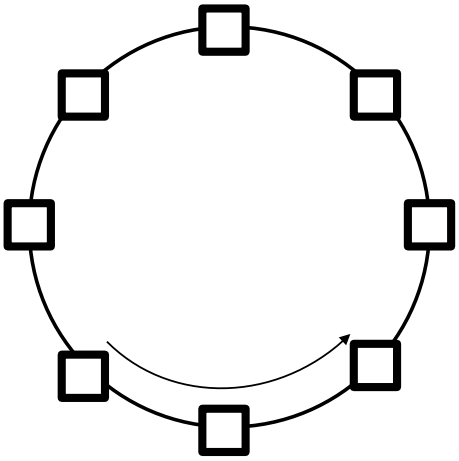
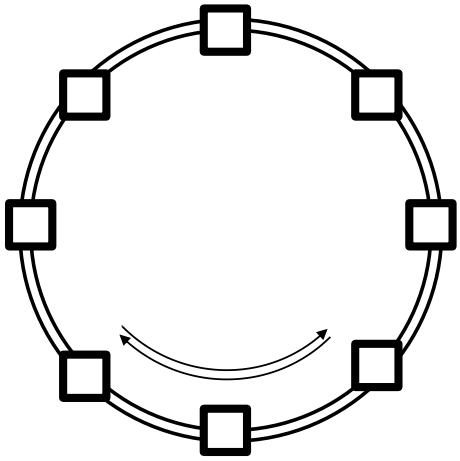
4. Interconnects [50 points]

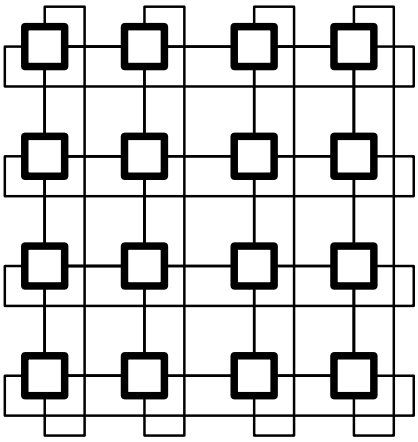
The following diagrams show four different topologies. In this question, assume that a packet can move from one node to the adjacent node in 1 cycle. Also, assume that the routing mechanism uses the shortest path from the source to the destination.



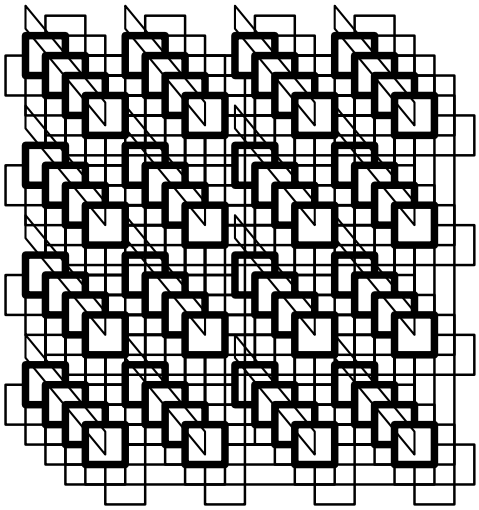
a) Uni-Directional Ring



b) Bi-Directional Ring



c) 2-D Torus



d) 3-D Torus

(a) What is the average latency of a uni-directional ring of size n, assuming a *uniform traffic pattern* where every node has an equal probability of sending a packet to every other node *without traffic contention*? No traffic contention means that a packet can always move toward its destination every cycle on its shortest path. For this and the following questions, assume that n is an **odd number**. Show your work.

$Avg(1 + 2 + 3 + ... + n - 1)$ $\frac{(n)(n-1)}{2(n-1)} = \frac{n}{2}$

(b) What is the average latency of a bi-directional ring of size n, assuming a uniform traffic pattern without traffic contention? Show your work.

For an odd number of n, the average latency is $\frac{(n+1)}{4}$.

(c) What is the average latency of a $n * n$ torus, assuming a uniform traffic pattern without traffic contention? Show your work. (*Hint: each ring in a torus is a bi-directional ring.*)

$2 * \frac{(n+1)}{4} = \frac{(n+1)}{2}$

(d) What is the average latency of a $n * n * n$ 3-D torus, assuming a uniform traffic pattern without traffic contention? Show your work.

$3 * \frac{(n+1)}{4}$