High-speed interconnection networks

- A high-speed interconnection network is important to supercomputers and HPC (high-performance computer system) clusters. The network provides low latency and high bandwidth connections.
- Bandwidth is the amount of data that can be transferred per second.
- The different methods of connecting the nodes form different topologies.
- The longest and shortest distance determines network diameter. Distance or hop(s) is the number of cable(s) a switch must travel to reach another switch.
- Ex: If a router, A, is directly linked by a cable to another router, B, then the shortest distance to travel from A to B is one hop.
- Radix is the amount of ports on a router/switch.

Network components

- A network interface controller (NIC) or network interface card provides connectivity capability between devices in a network.
- Both terms, switch and router, can be used interchangeably.
- It connects multiple networks together; it can be connected to other routers.
- Switches are connected by network cables.
- There are two types of wires/cables: copper and optical.
- Copper cables cannot transfer data over long distances compared to optical cables (due to signal loss). However, copper cables are cheaper to produce.
- The length of the cable has no impact on the performance.

N-dimensional network

- Each switch has a few nodes connected to it (usually one).
- In an N-dimensional network, each switch is directly linked to 2n switches.
- **Trous** networks are networks that contain wrapped-around links.
- “An ideal torus network uses the same number of nodes along each dimension to maintain balance” ([https://clusterdesign.org/torus/](https://clusterdesign.org/torus/)).
1. **1D Torus**: In one dimension, nodes are connected in a closed loop, forming a simple circle. Communication can occur in two directions: $+x$ and $-x$. Essentially, a 1D torus is equivalent to a ring interconnection.

2. **2D Torus**: In two dimensions, nodes are laid out in a rectangular lattice with $n$ rows and $n$ columns. Each node is connected to its four nearest neighbors ($+x$, $-x$, $+y$, and $-y$). The total number of nodes in a 2D torus is $n^2$.

3. **3D Torus**: In three dimensions, nodes form a three-dimensional lattice resembling a rectangular prism. Each node is connected to its six neighbors ($+x$, $-x$, $+y$, $-y$, $+z$, and $-z$). Each edge of a 3D torus consists of $n$ nodes.

**Fat-tree network**

- It optimizes communication efficiency.
- A Fat-tree network has a radix of $k$, and each router has $k/2$ nodes.
- A pod is a group of $k/2$ switches (at each level), and the max number of pods = $k$. 