INTERCONNECTION TECHNOLOGIES

Non-Uniform Memory Access Seminar

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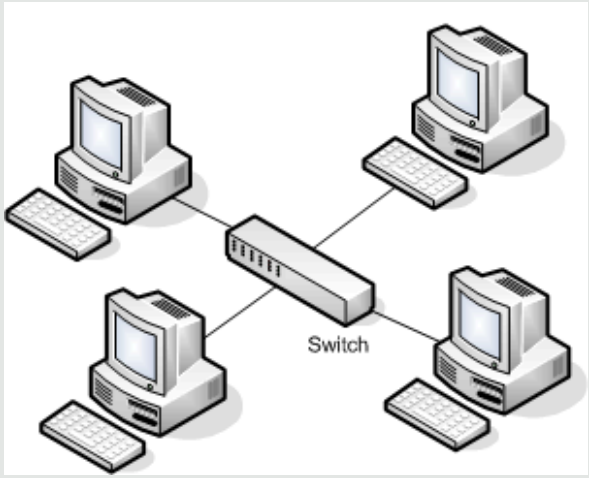
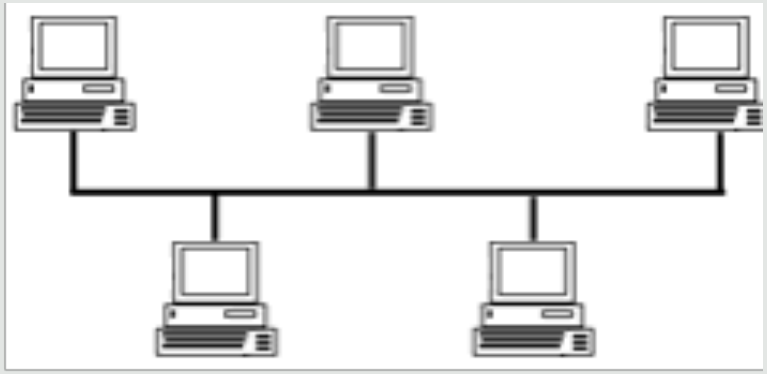
Agenda

- Network topology
- Logical vs. physical topology
- Logical topologies
  - InfiniBand
  - Crossbar switch
- Interconnection technologies in NUMA system
  - AMD Hyper-Transport (HT)
  - Intel Quick-Path Interconnect (QPI)
  - NumaLink

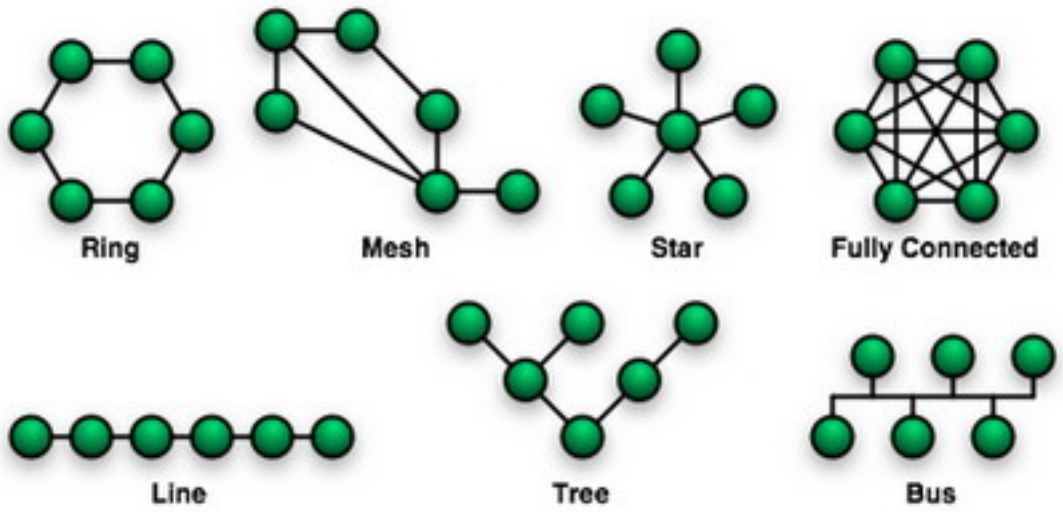
Network Topology

- Computer system or network equipment are connected to each other

Physical topologies	Logical topologies
	

Logical topologies

- Point-to-point
- Bus
- Daisy chain
- Ring
- Star
- Mesh
- Tree
- Hybrid
- Hypercube



Point-to-point topology

- Connects two nodes directly together
- Types:
  - simplex
  - half-duplex
  - full-duplex

    + simple

    + fast

    + medium is not shared

    - support only two nodes

Bus topology

- Common medium (central bus) where the rest of nodes separately connected

  + more than one node

  + costs

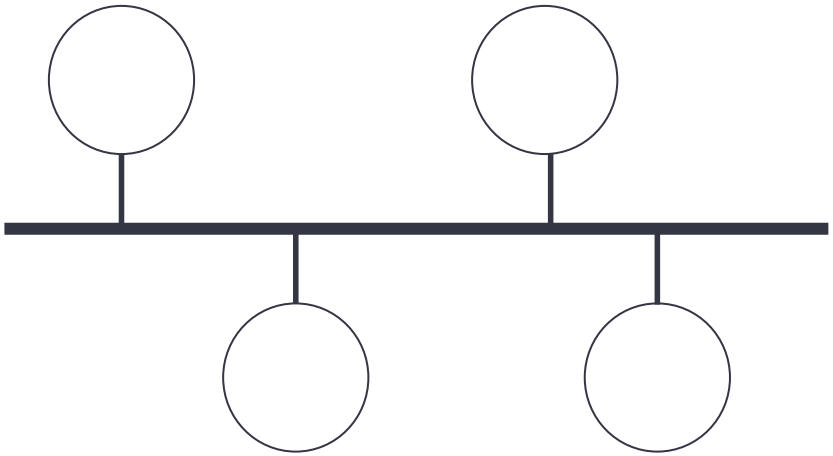
  - small networks

  - limitation of nodes

  - data collision

  - depended on central bus

  - security



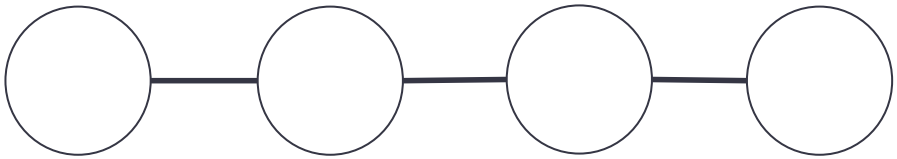
Daisy chain topology

- Node connects one after another

  + simple

  + scalability

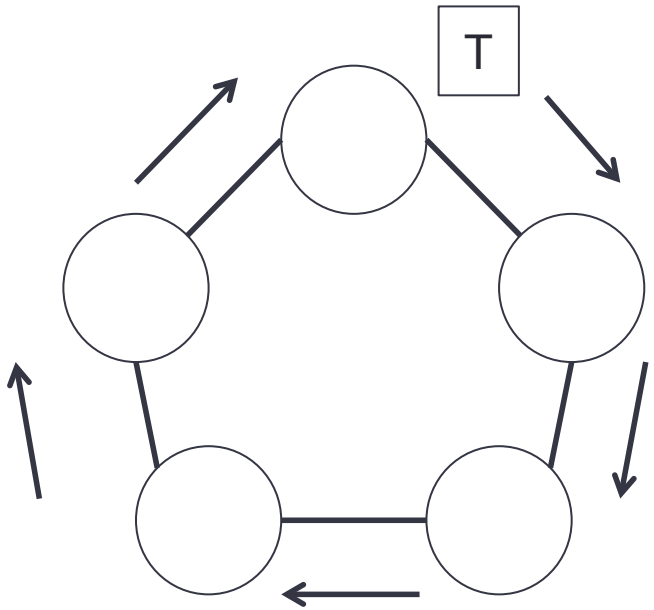
  - slow for the opposite end of the chain



Ring topology

- Each node has two connection: to its nearest neighbors
- Data transmission happens indirectly
- Sending and receiving data with the help of the token
- Clockwise
- Double ring

  + organized
  + no date collision
  + no server
  + easy to add components
  - slow
  - dependent



Star topology

- Each node connects to a central point via a point-to-point link
- Central device:
  - hub
  - switch
- Independent access

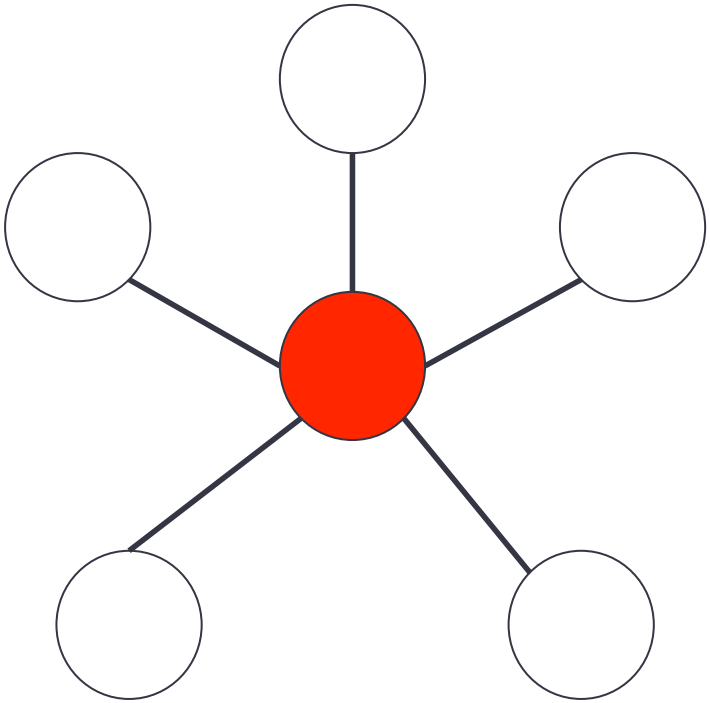
  + centralized management

  + failure of a node does not affect

  - central devise failure affect all the network

  - cost

  - number of nodes depends on capacity of central device



Mesh topology

- Nodes are connected directly to another nodes
- Types:
  - fully-connected
  - partly-connected

    + simultaneously

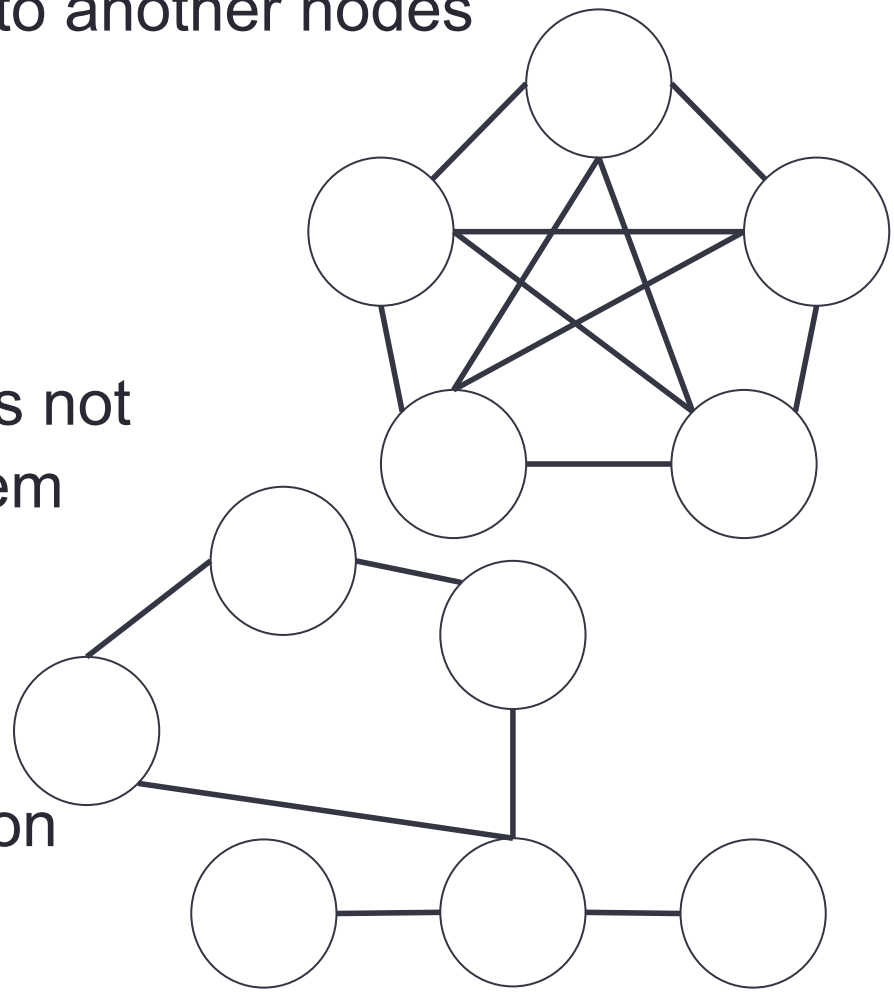
    +failure of one node does not affect on the system

    + easy to modify

    - high redundancy

    - cost

    - set-up and administration is difficult



Tree (hierarchy) topology

- Star topology are connected using Bus topology

  + expansion is easy

  + easy to manage and maintain

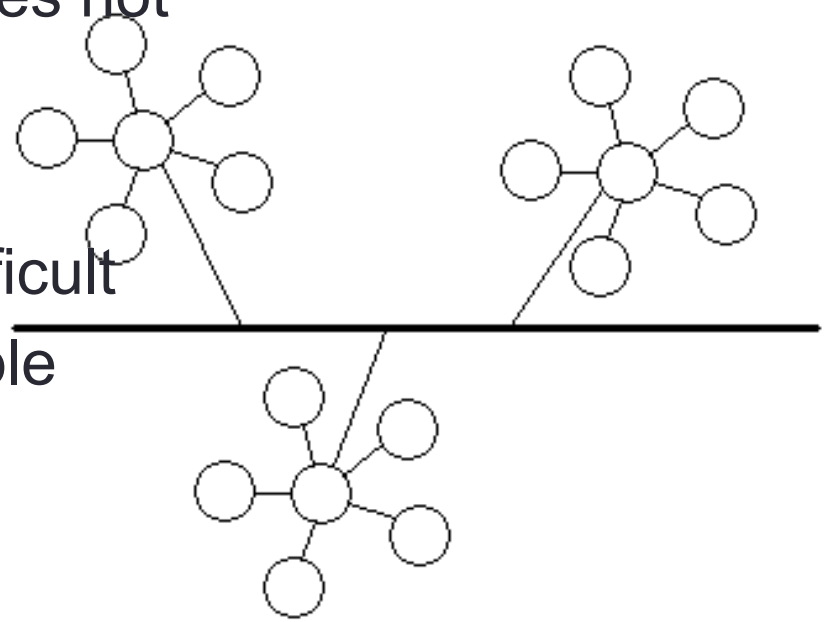
  + error detection and correction are easy

  + failure of one segment does not affect to the system

  - central bus

  - maintenance becomes difficult

  - scalability depends on cable



Hybrid topology

- Combines two or more topologies
- Reap their advantages

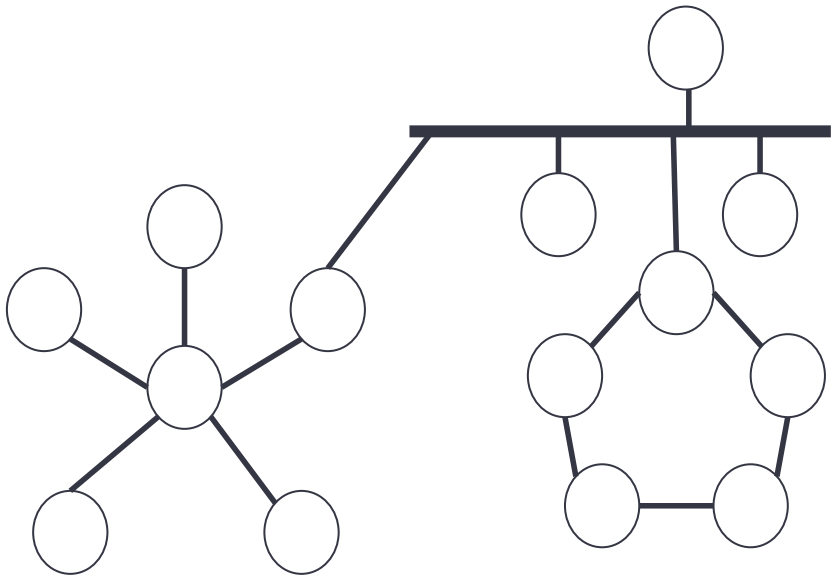
  + scalable

  + flexible

  + effective

  - complex

  - cost



Hypercube topology

- The distance between any two nodes is at most log(p)
- Each node has log(p) neighbors

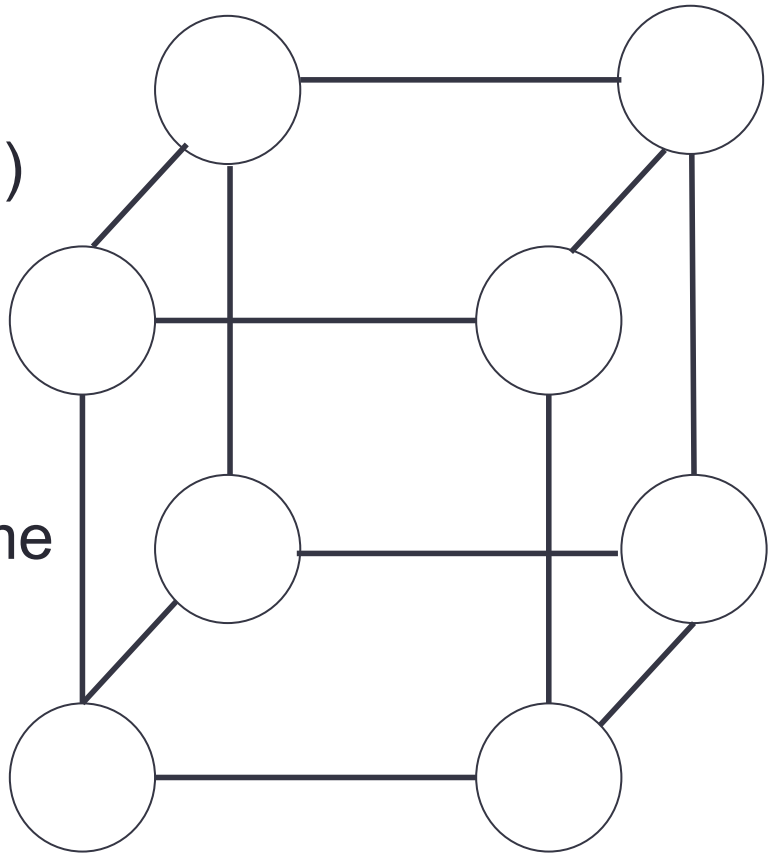
  + only log(p) neighbors

  + the longest route is log(p)

  + excellent connectivity

  - physical network infrastructure is ignored

  - building one node at a time

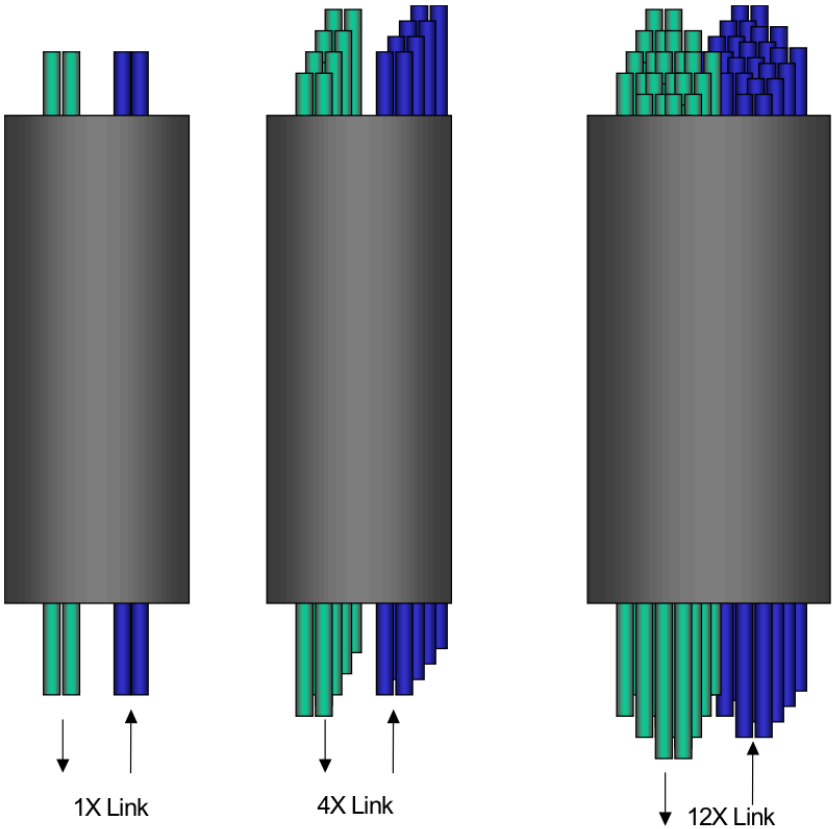


InfiniBand (IBA)

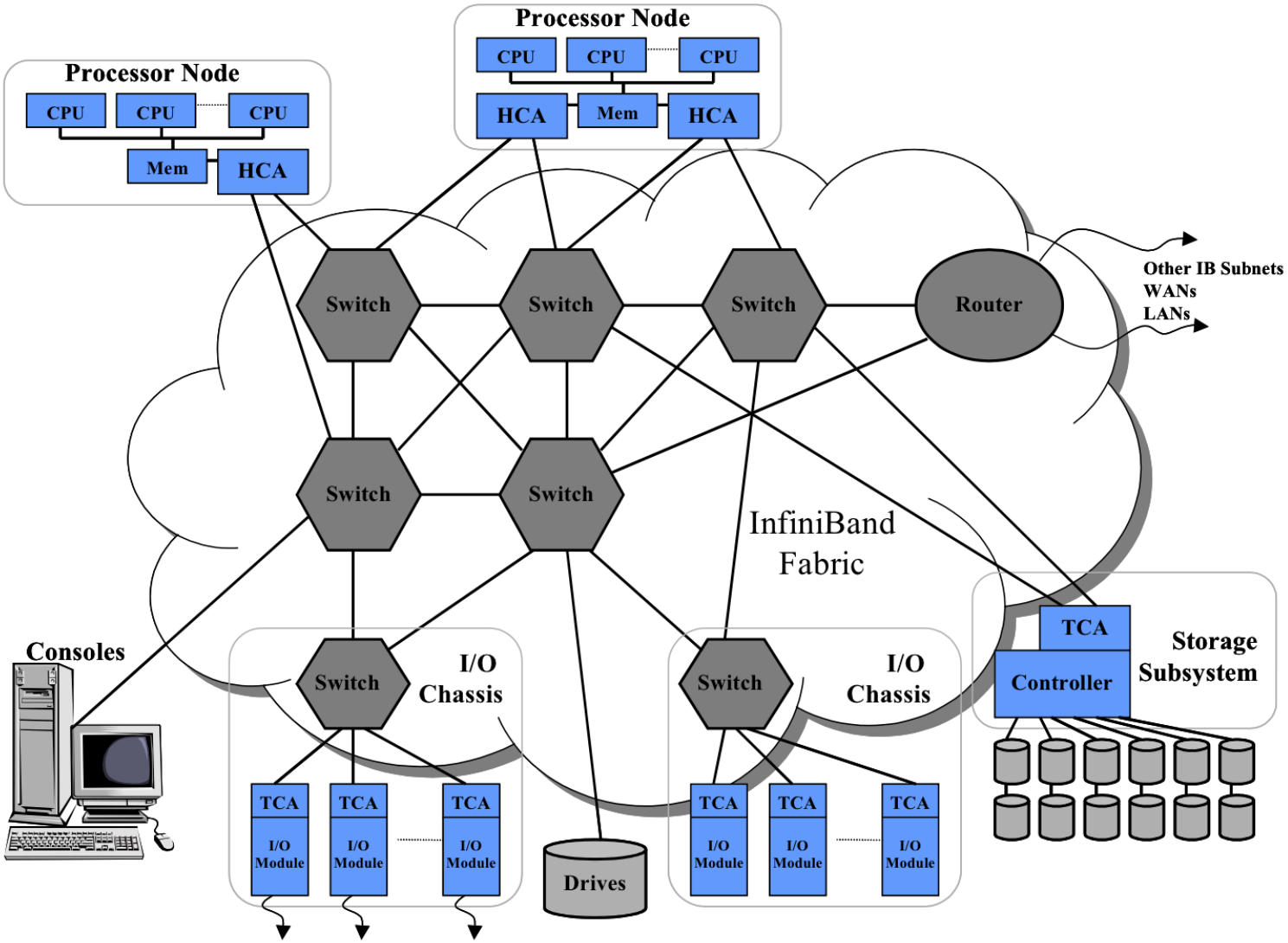
- High bandwidth
- Low latency
- Bi-directional
- “Shared-nothing” architecture
  - Not able to address directly
- Support for up to 64,000 addressable devices

IBA bandwidth

- 1X Link – 500MB/sec
- 4X Link – 2GB/sec
- 12X Link – 6 GB/sec



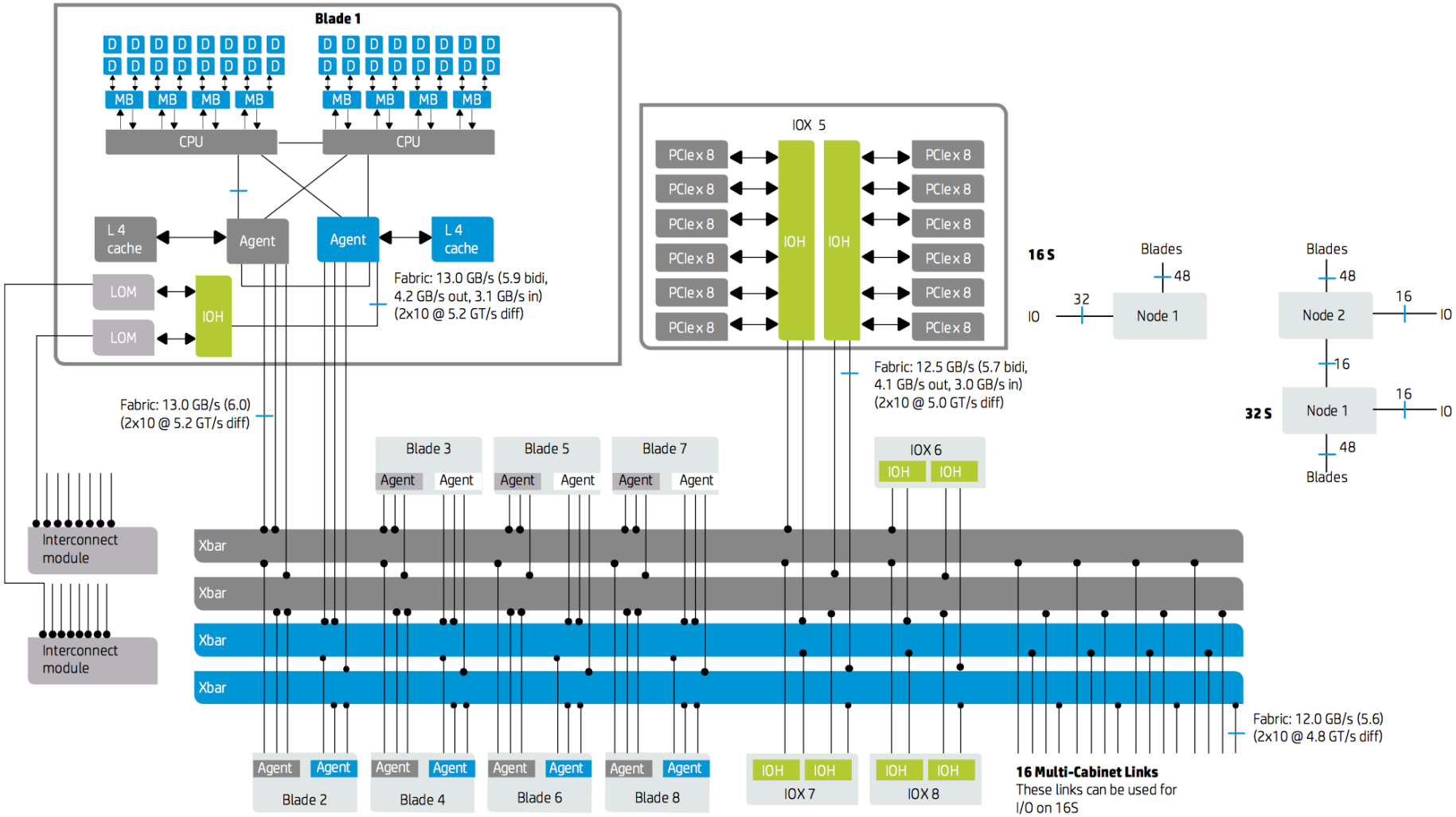
IBA System Fabric



IBA

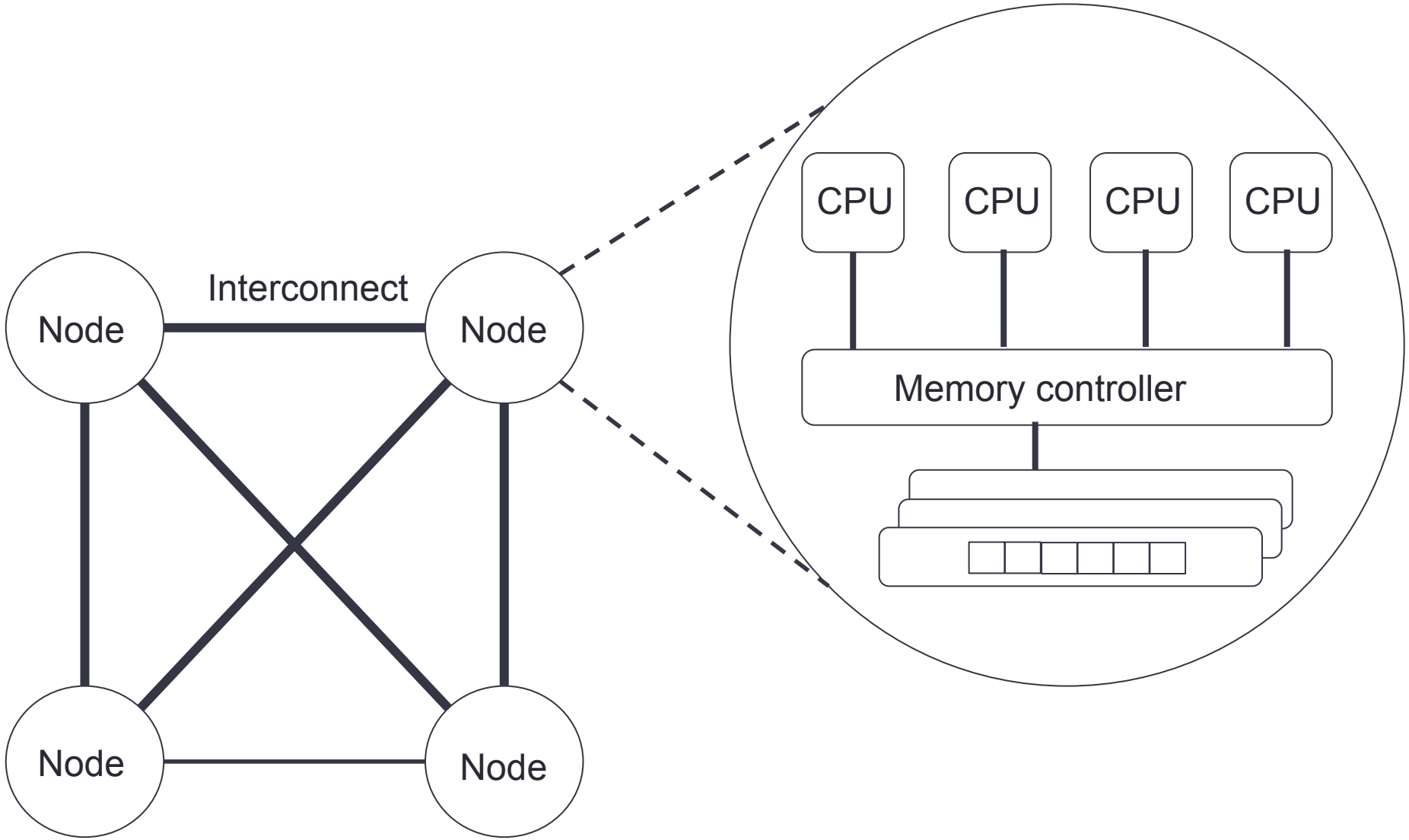
- Used by 43% of the systems on the Top-500 list of supercomputers (Nov. 2010)
- Intel® Xeon Phi™
- Mellanox ConnectX IB

Crossbar switch (Integrity Superdome 2)

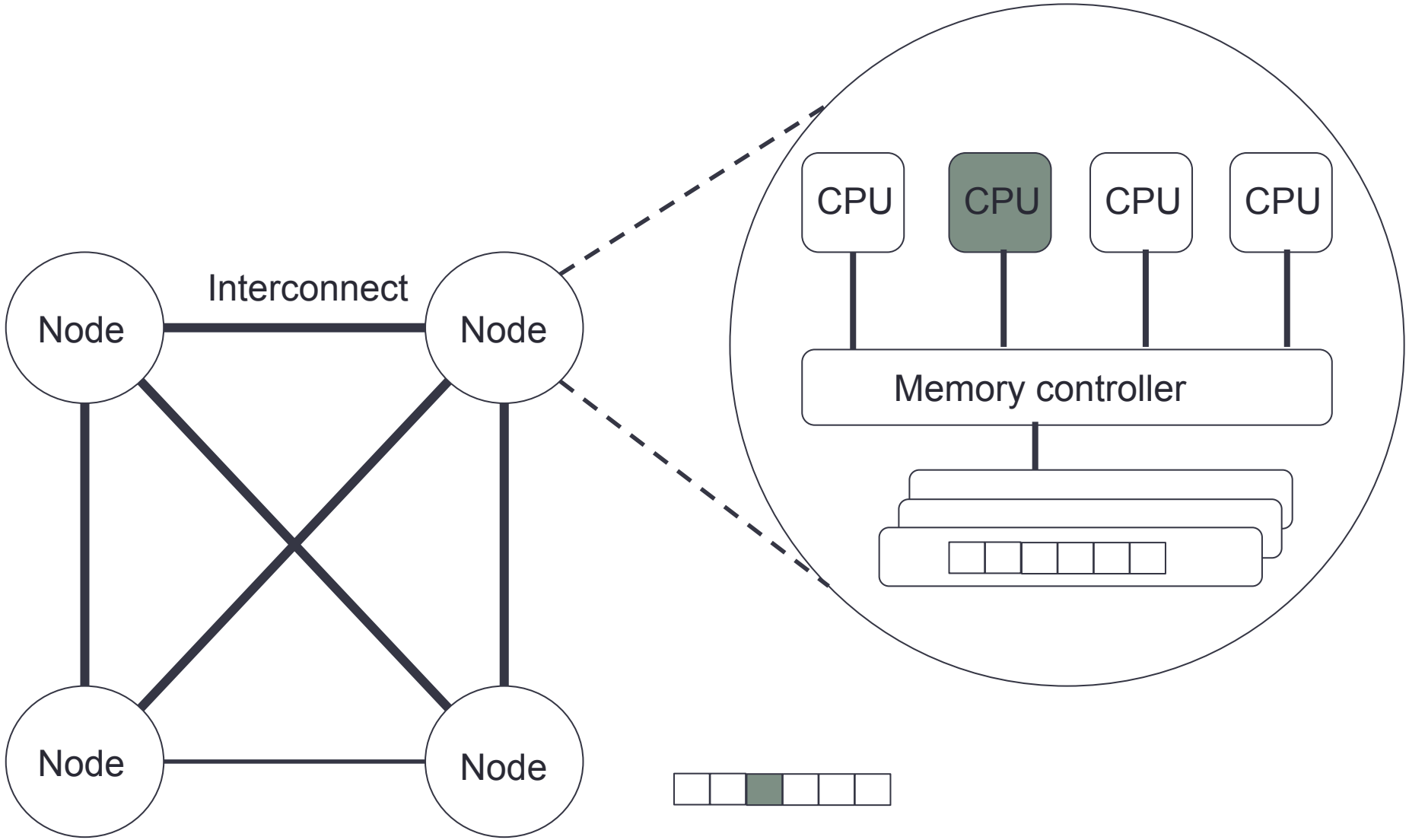


INTERCONNECTION TECHNOLOGIES IN NUMA

Non-Uniform Memory Access



Interconnectors



NUMA Interconnectors

- AMD Hyper-Transport (HT)
- Intel Quick-Path Interconnect (QPI)
- NumaLink

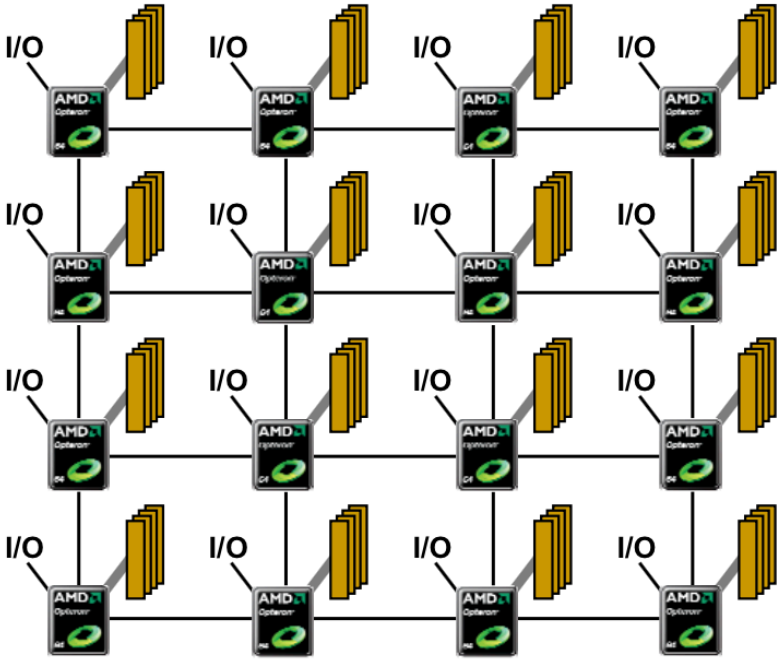
AMD Hyper-Transport (HT)

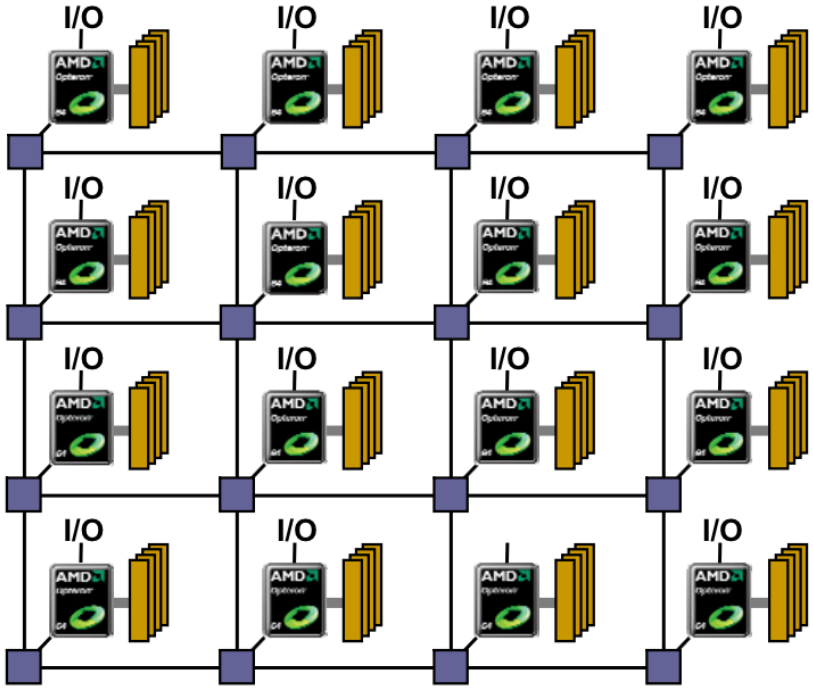
- High bandwidth
- Low latency
- Bi-directionally
- Multiple configuration
  - Daisy chain
  - Star
  - Mesh
- HyperTransport 3.10

AMD Hyper-Transport (HT)

- Minimal chain: two nodes
- Maximal chain: 32 nodes
- Up to 3.2 GB/sec over 8-bit I/O link
- Up to 12.8 GB/sec over 16-bit I/O link
- Up to 25.6 GB/sec over 32-bit I/O link

HT Implementation





AMD Hyper-Transport (HT)

- Opteron
- Athlon 64
- Phenom

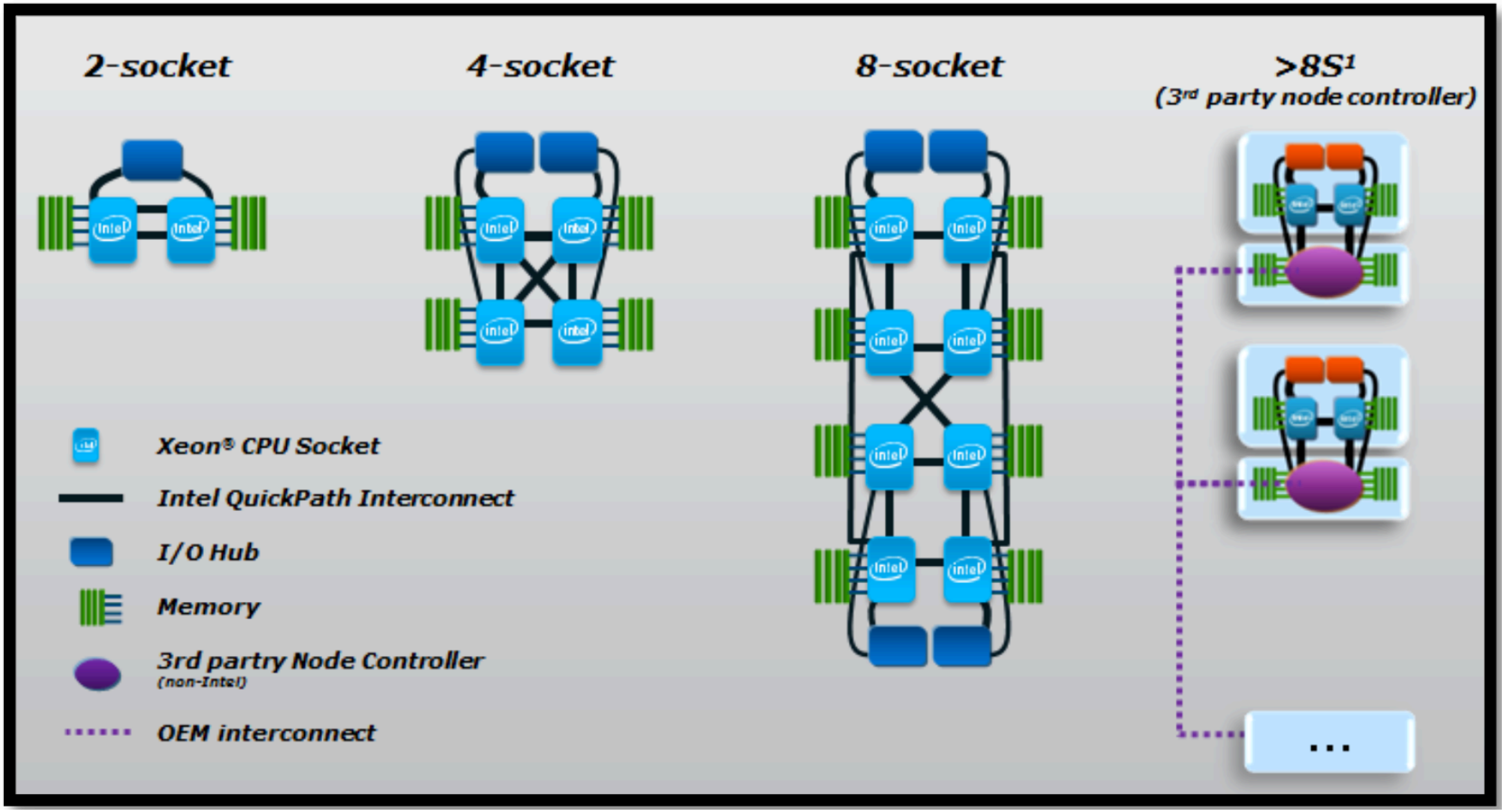
Intel Quick-Path Interconnect (QPI)

- High bandwidth
- Low latency
- Bi-directional
- Up to 25.6. GB/sec per link
- High scalable

QPI Physical Layer

- Two 20-lane point-to-point data links
- Full duplex with a separate clock pair in each direction
- 42 signals
- Total number of pins is 84
- 20 data lanes are divided onto four "quadrants" of 5 lanes each

Intel Quick-Path Interconnect (QPI)



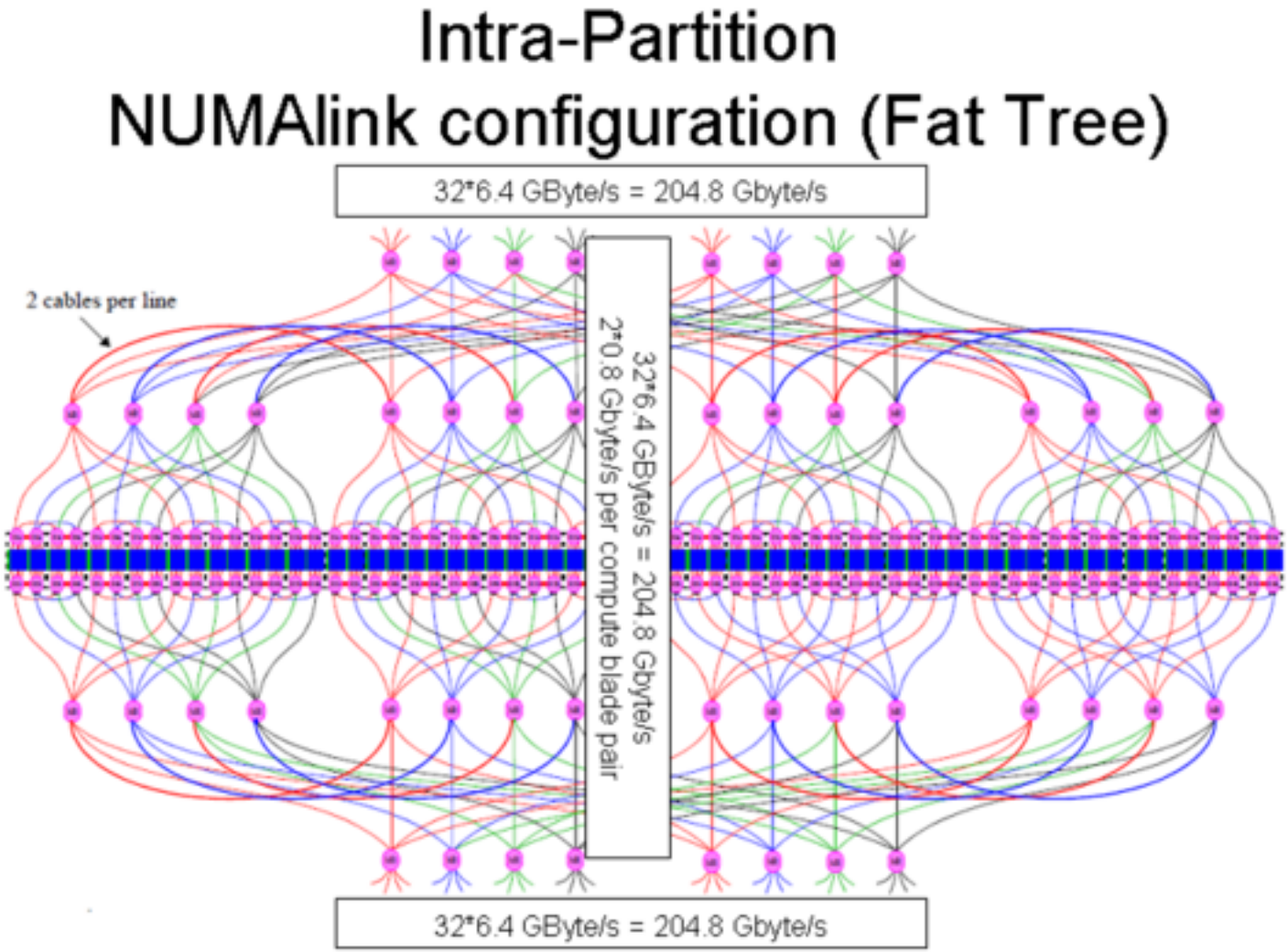
Intel Quick-Path Interconnect (QPI)

- Xeon
- Core i7
- Itanium

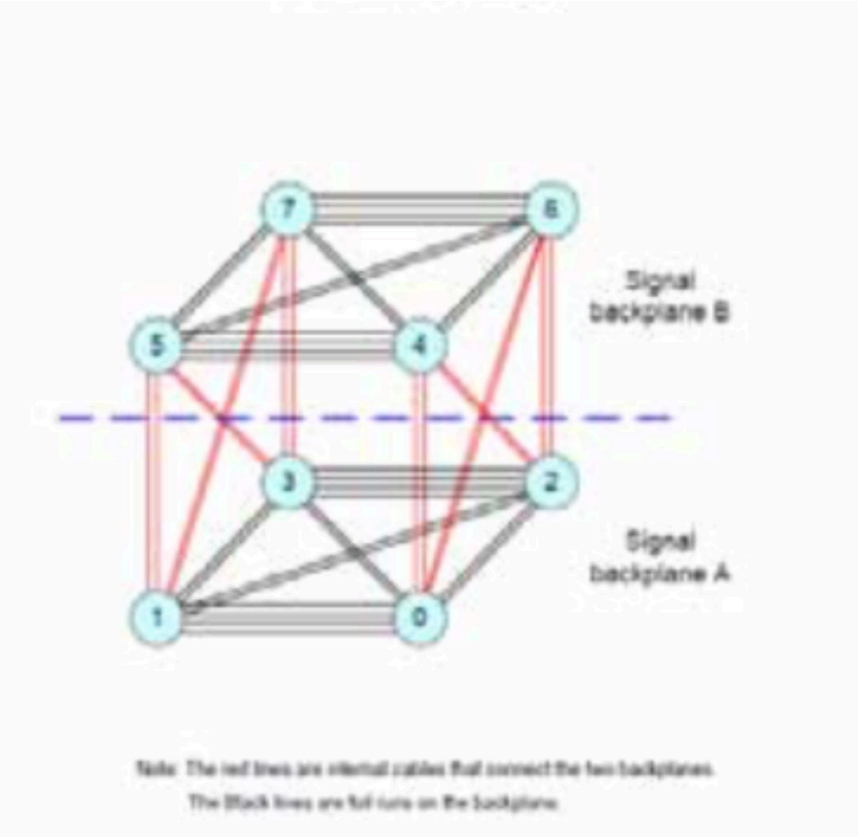
SGI Numalink

- High bandwidth
- Low latency
- Bi-directional
- Connected into the memory infrastructure of the system
- Reduce one-way request to memory
- Numalink3 3.2 GB/sec
- Numalink4 6.4 GB/sec
- Different topology
- Max 2048 nodes

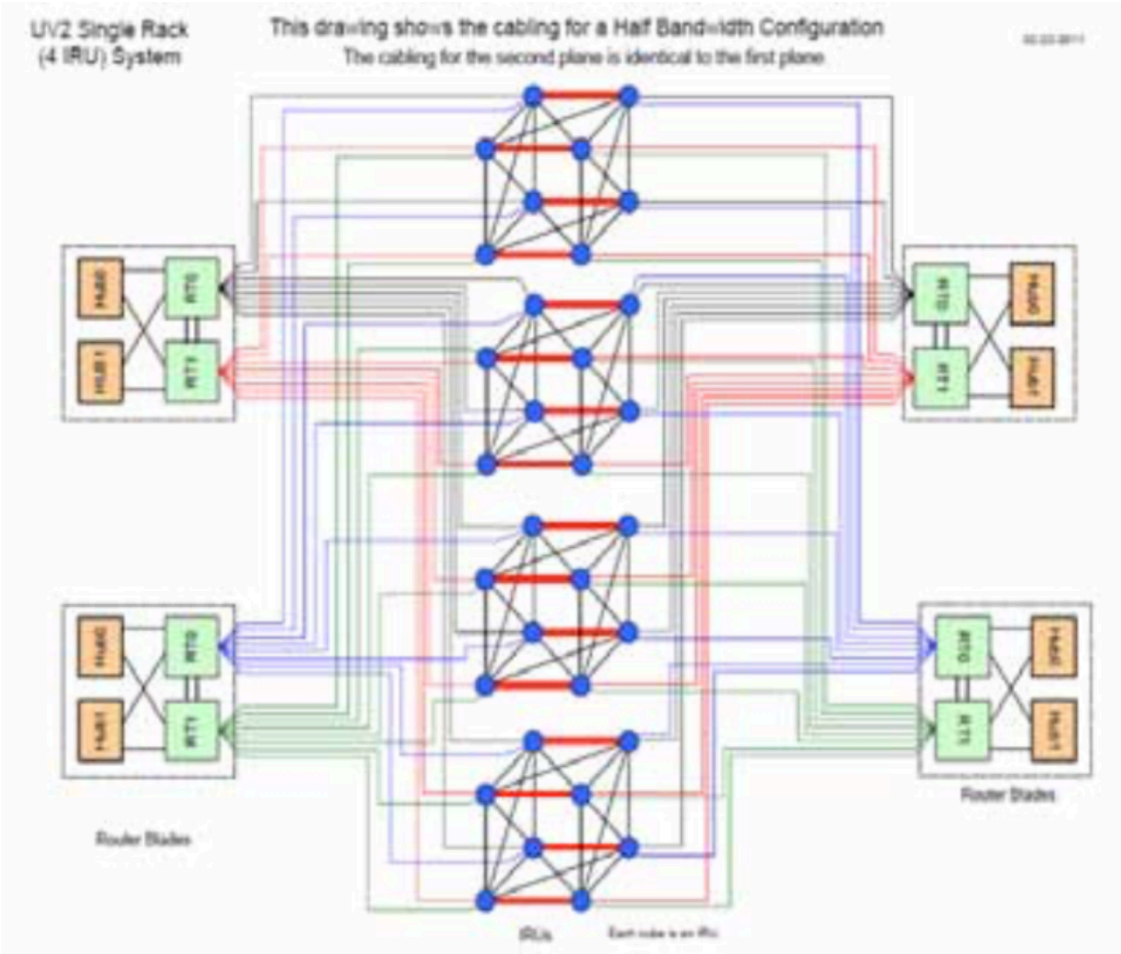
SGI Numalink. Tree configuration



SGI UV 2000. Hypercube configuration



SGI Numalink. Hypercube configuration



SGI Numalink

- Altix servers and supercomputers

Questions?