SpaceWire Network Topologies

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Trade-offs

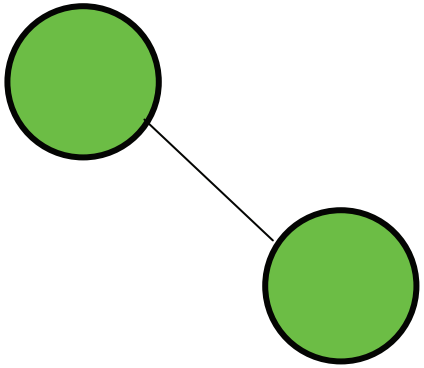
SpaceWire offers many new possibilities to choose the right balance between a number of parameters:

- Performance
- Fault-tolerance
- Harness mass
- Power consumption
- Component cost and availability
- Lead time to flight

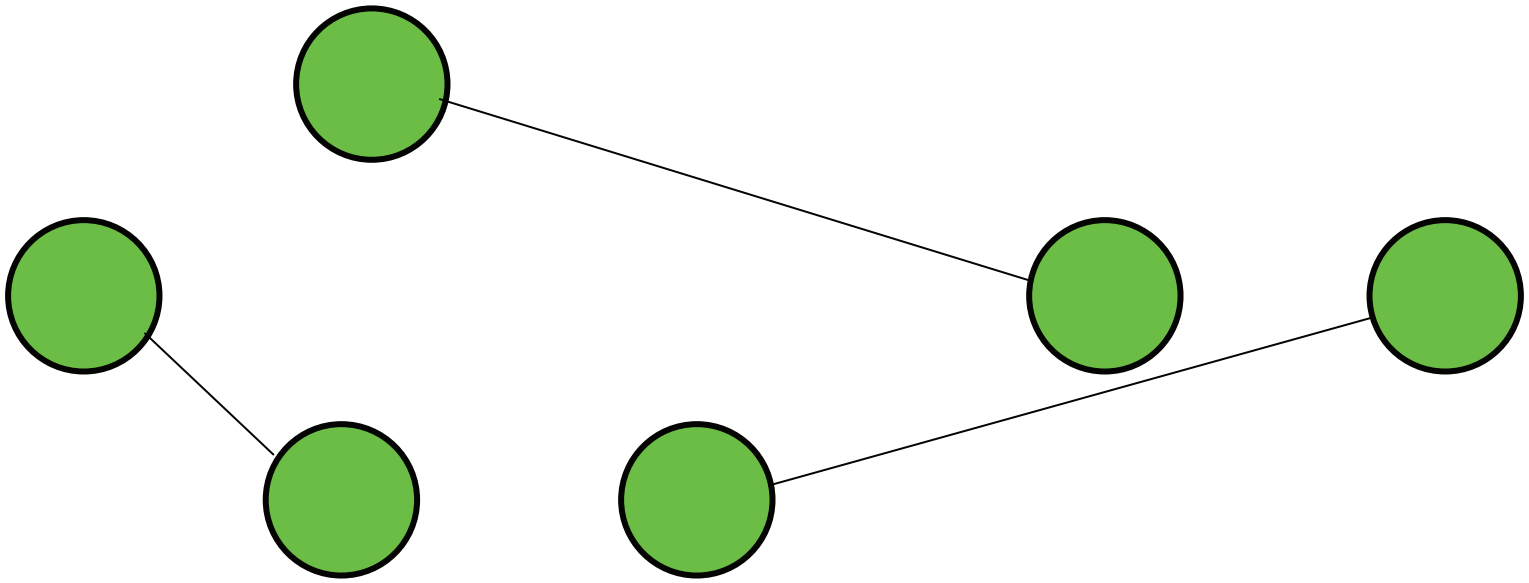
You have to make this choice

- This paper may give some ideas to help you

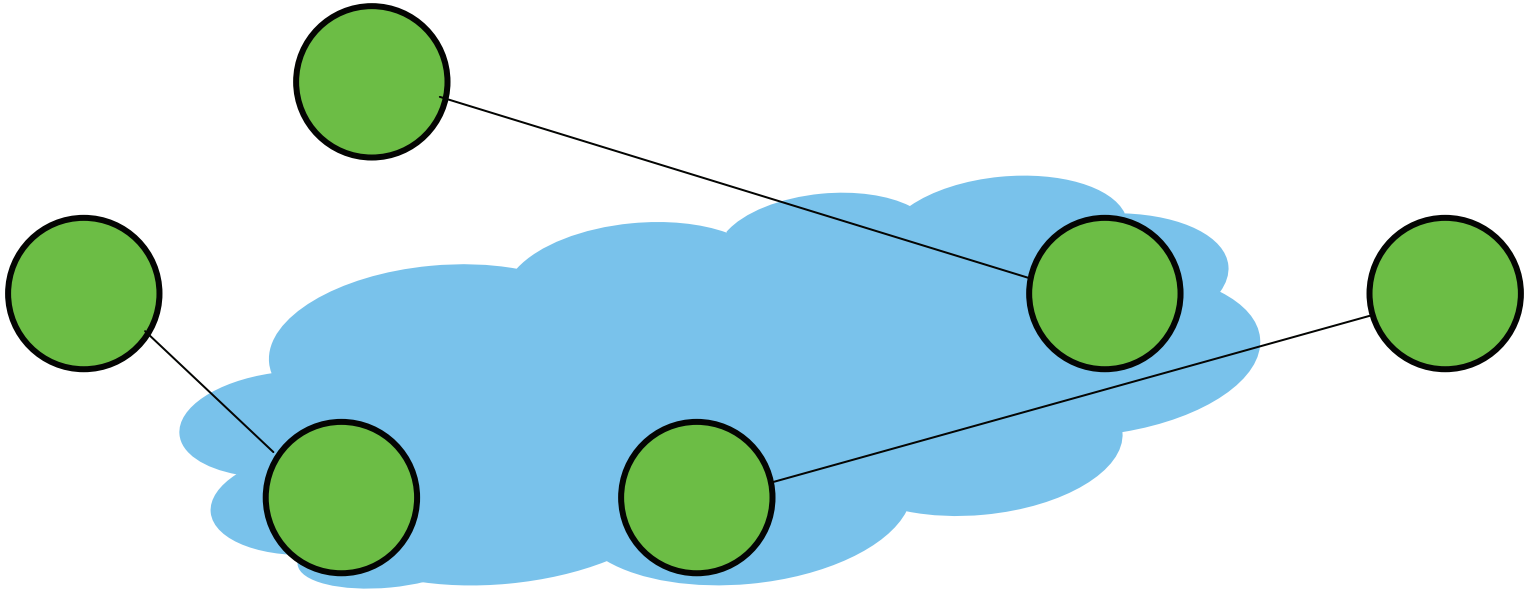
Point-to-point



Point-to-point, no Routing



Non-SpaceWire cloud



- There actually is a network between the SpaceWire links
- But that network is not SpaceWire

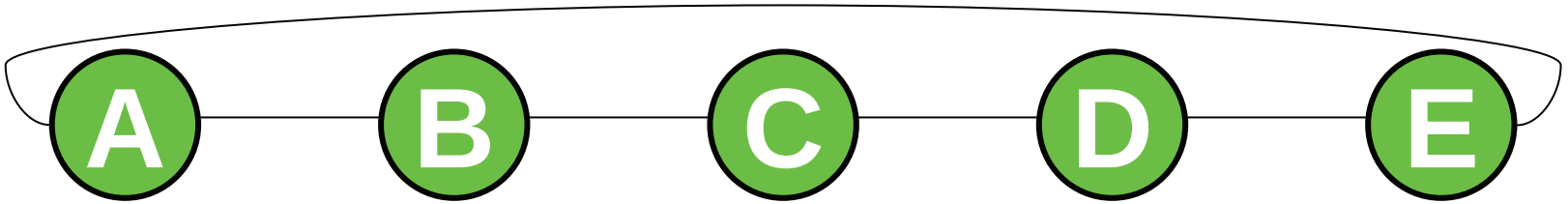
(Daisy-) Chain

- **Simple, but requires a routing switch at each node**

(Daisy-) Chain

- **A fault can split the chain into two**

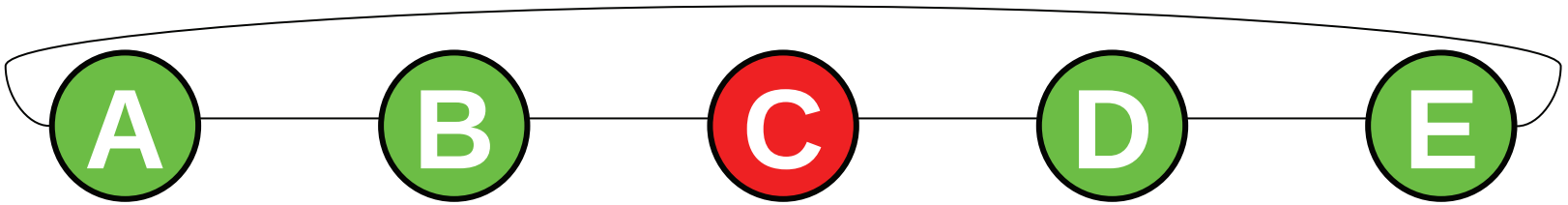
Ring



Looping the Chain to make a Ring

- Reduces number of hops
- Allows “Spatial Re-Use”

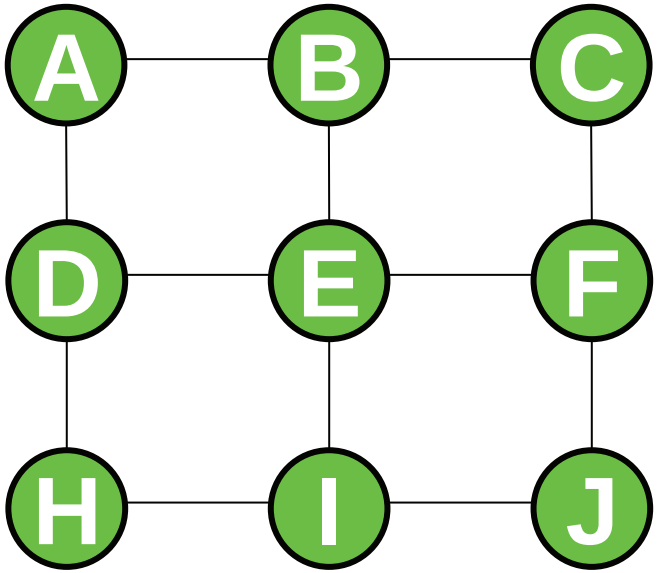
Ring



Looping the Chain to make a Ring

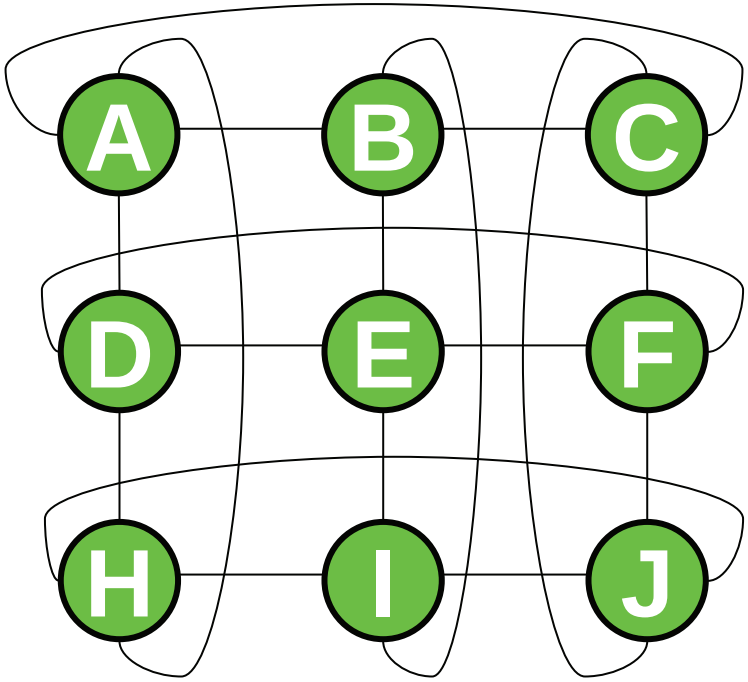
- **Also removes the single points of failure**
- **D E A B is still a valid Chain if C fails**

Grid: (Multi-dimensional Chain)



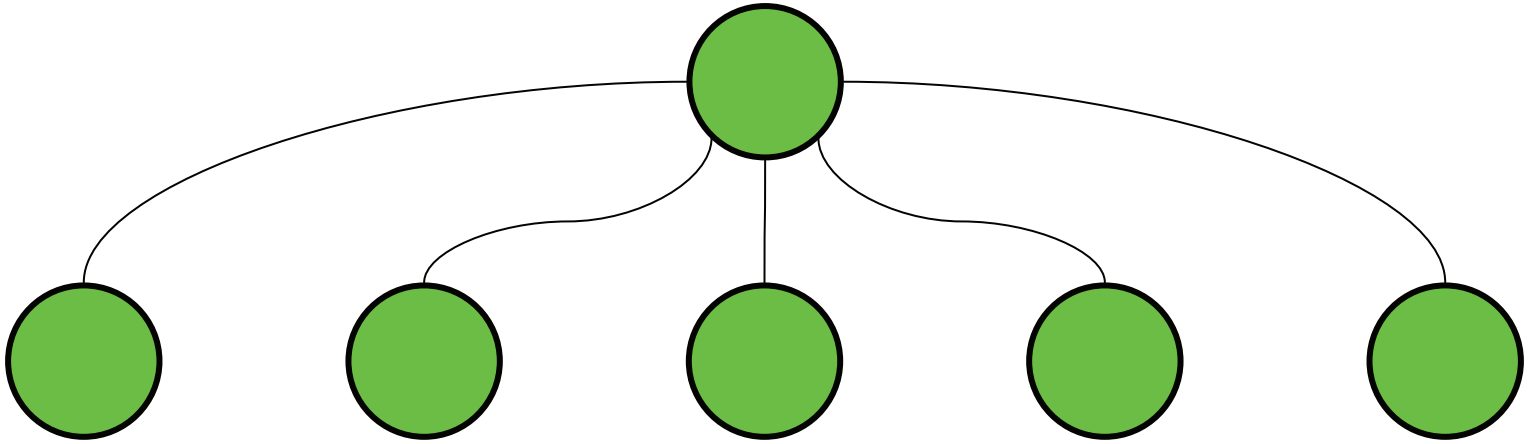
- More ports per node
- Further reduces number of hops
- Further improves fault-tolerance

Toroid: Multi-dimensional Ring



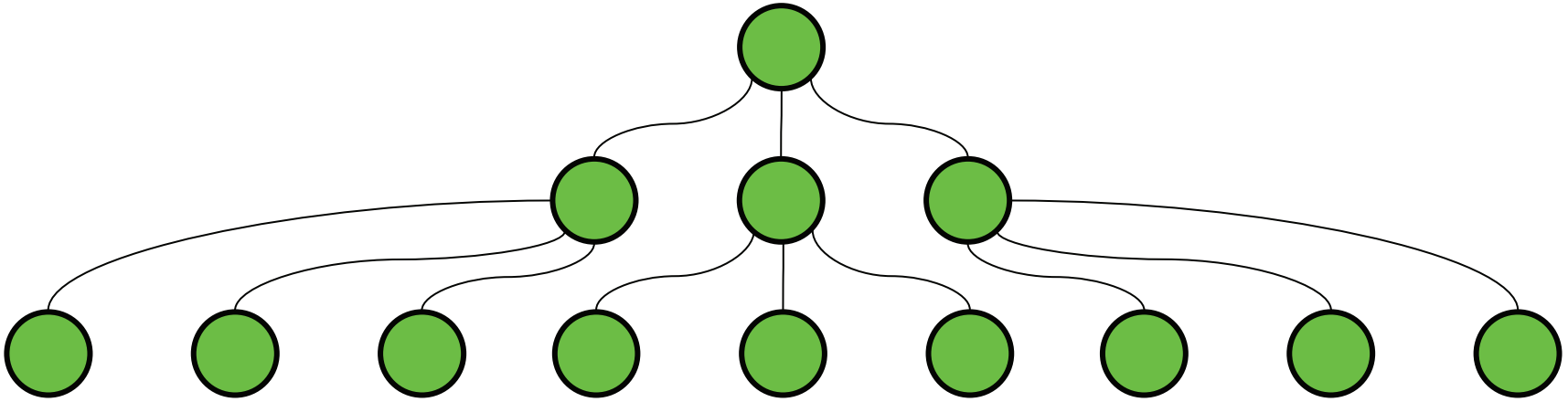
- Still more ports per node
- Still further reduces number of hops
- Still further improves fault-tolerance

Tree: Central Routing Switch / Concentrator



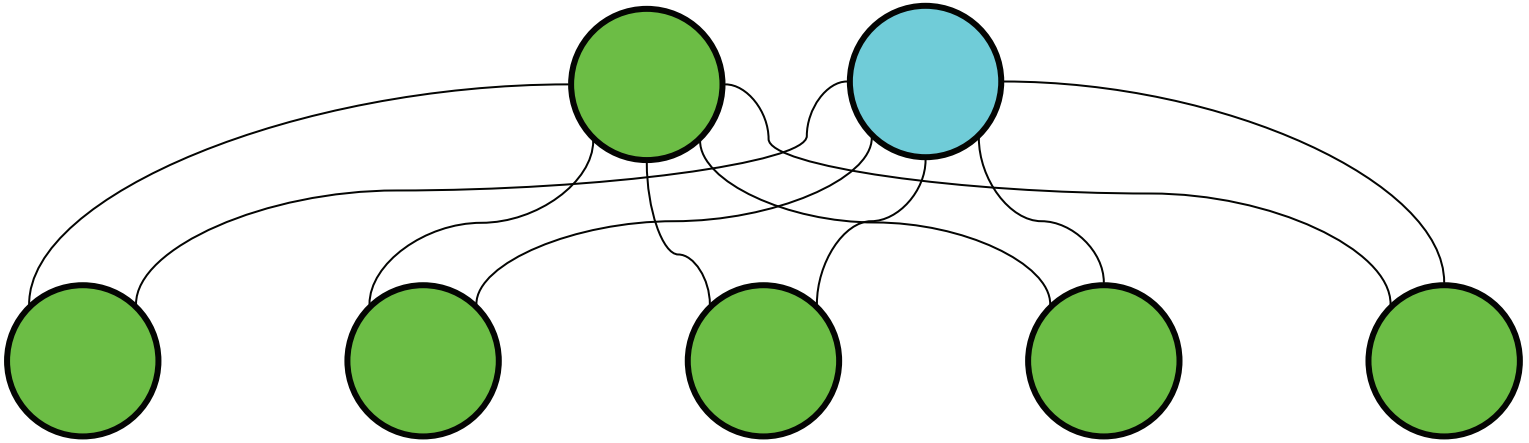
- **Simple distinction between nodes and routing switches or concentrators**

Tree: Central Routing Switch with Concentrators



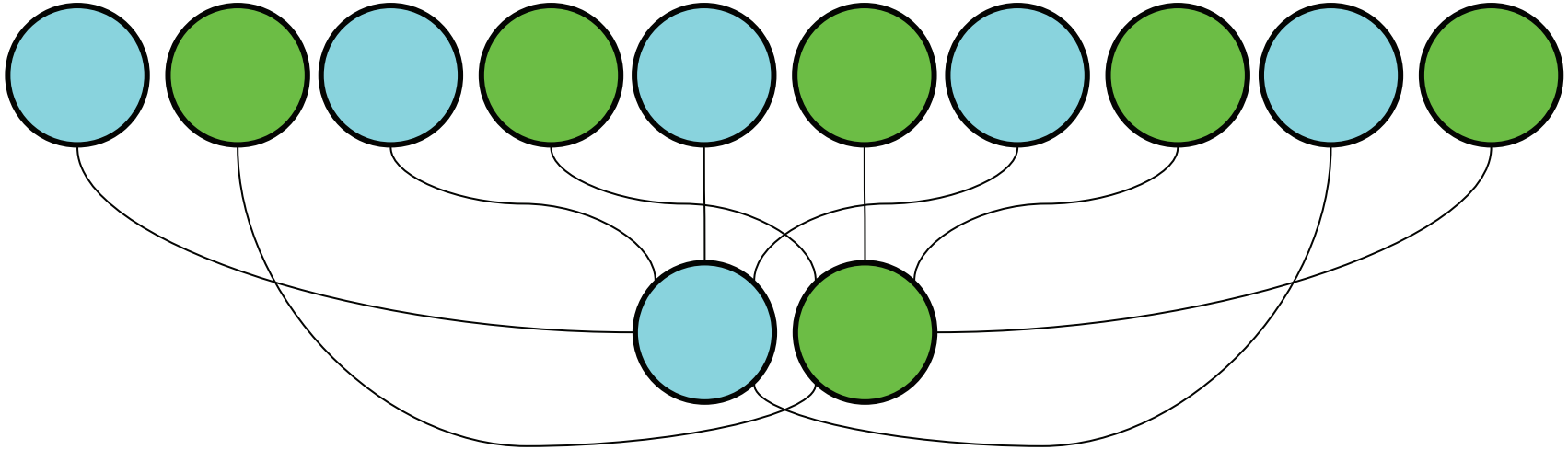
- Can be good if most traffic is to/from the root
- Root can be bottleneck if nodes need to communicate with each other
- Not fault-tolerant

Tree: Redundant Central Routing Switch



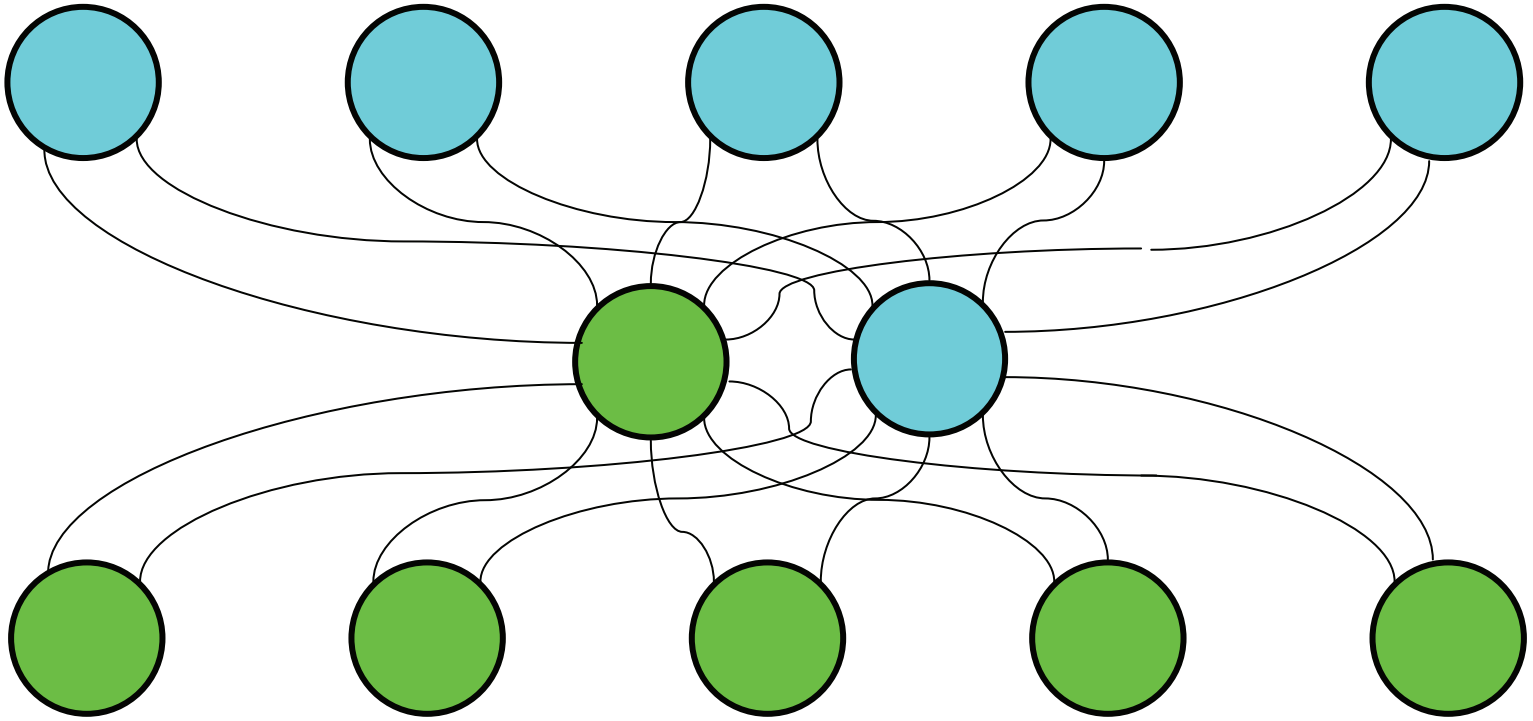
- **Starts to add lots of cables**

Cold Redundant System



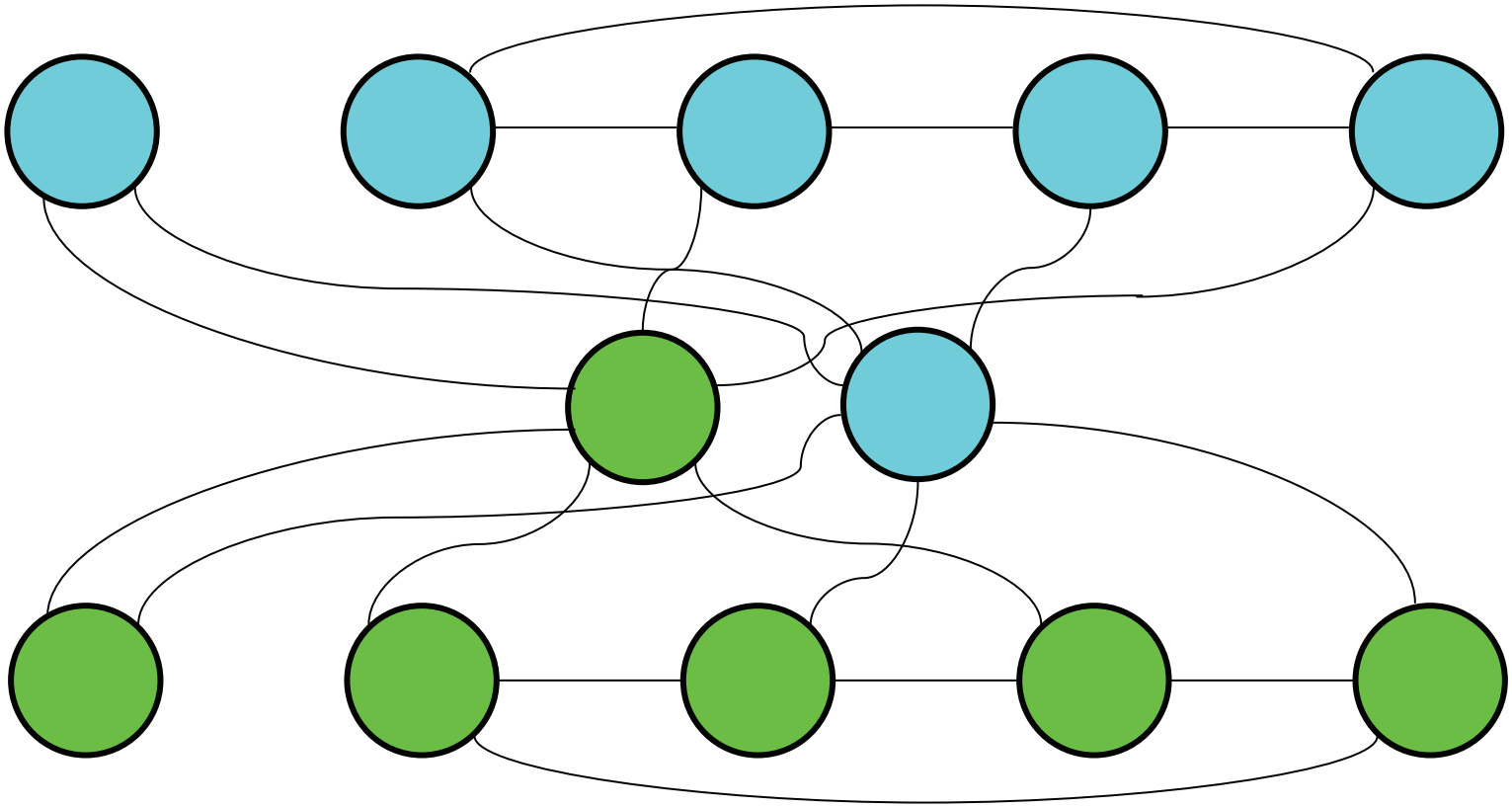
- Either Nominal system in use
- Or Redundant system in use
- Not part Nominal part Redundant

Cold Redundant System



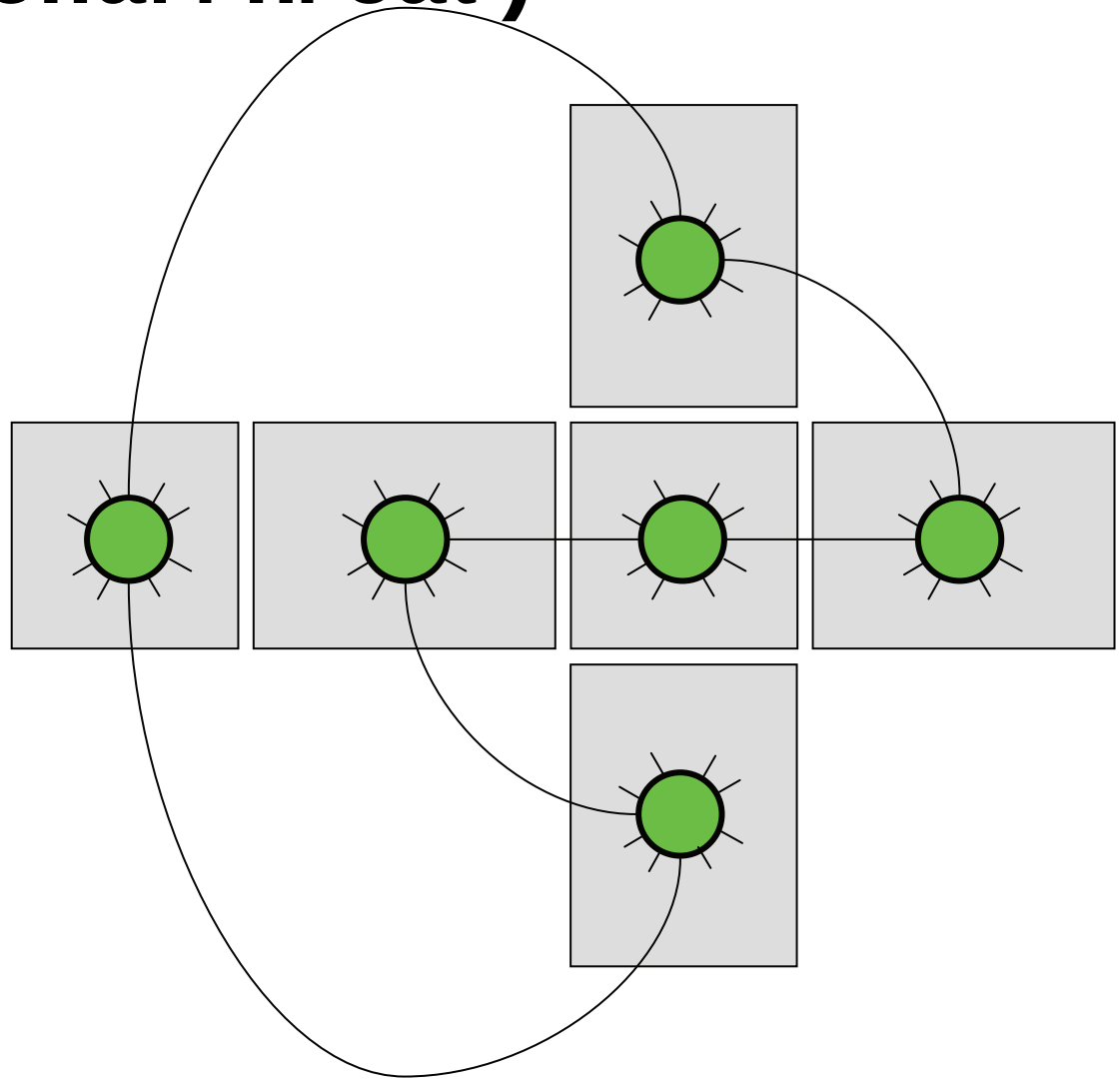
- More cables
- But can use some Nominal and some Redundant nodes with either switch

Hybrid Cold Redundant

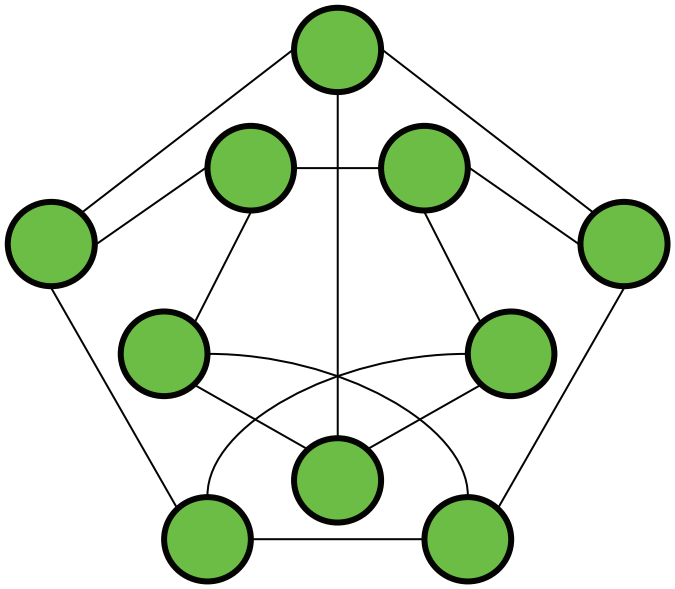


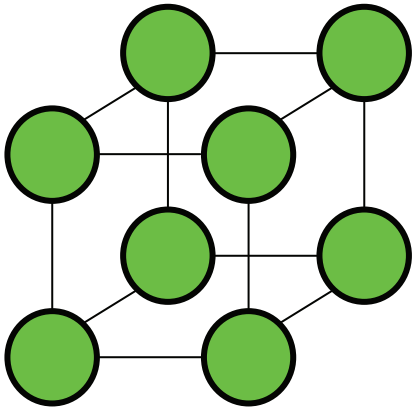
- Same number of cables
- Possibly shorter cables in ring
- Fewer ports needed in central routing switches

Hybrid topology (notional PnPSat)



Further Study: Graph Theory





Petersen Graph

- 3 ports per node
- Two hops to any node
- Ten nodes

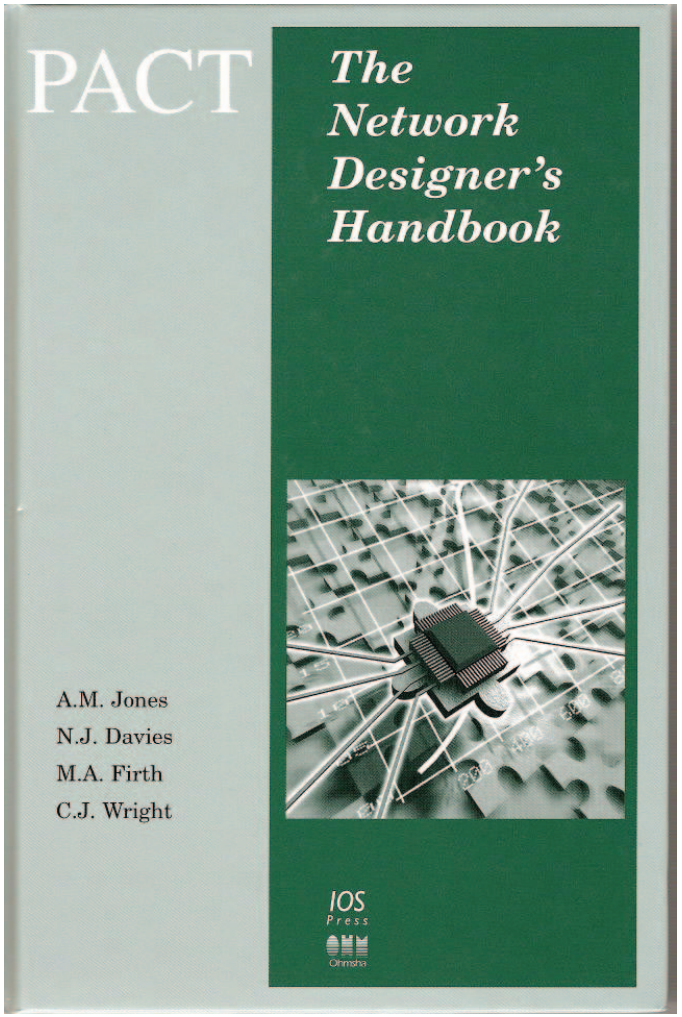
Cube

- 3 ports per node
- Three hops between corners
- 8 nodes

Further Study: Network Designer's Handbook

- Written for IEEE 1355
- Based on Opnet simulations of many networks
- Backed up by building a network with 1024 nodes

- Results may not carry exactly to SpaceWire
- But they will inform SpaceWire users



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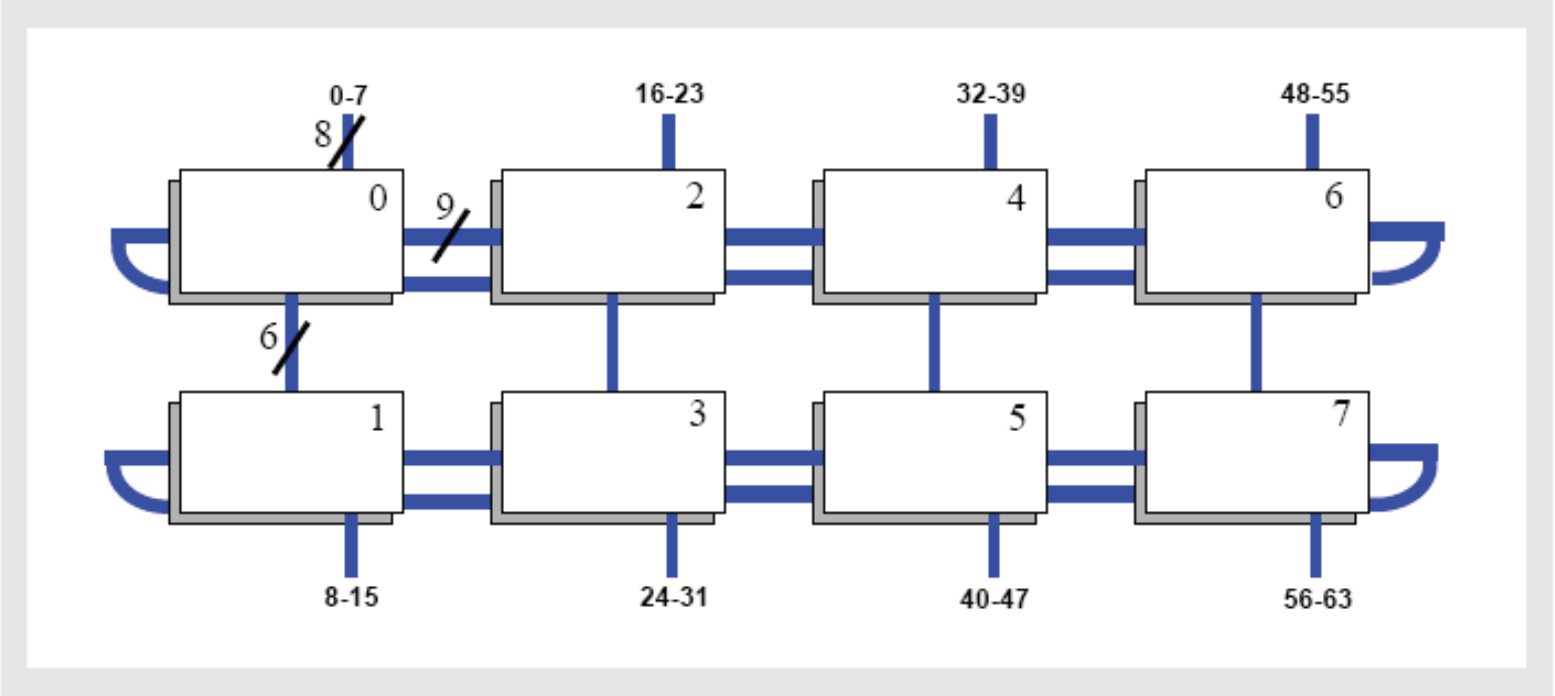
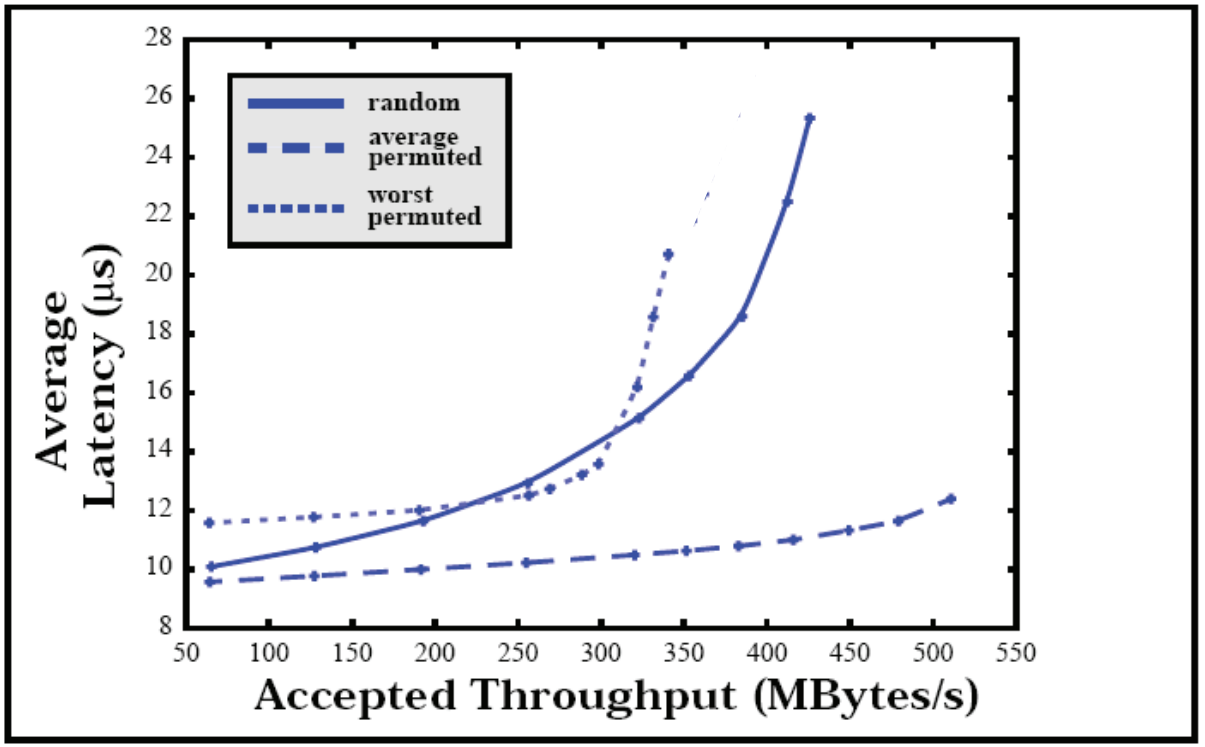


- Two-dimensional ring/torus
- 8 external ports per 32-port switch
- 24 ports making torus network between switches

Further Study: Network Designer's Handbook



- More traffic results in longer delays
- Excess traffic leads to excessive delays/gridlock
- Some networks are better than others!

Conclusions

- SpaceWire's topological flexibility brings new opportunities
- Possibilities range form daisy chains to large centralized routing switches, with many in between
- Hybrid combinations of different topologies may be appropriate for many missions
- Work on IEEE 1355 together with insights from Graph Theory may help SpaceWire users
- Result should be optimal balance between performance, cost, mass, fault-tolerance and lead-time