

SpaceWire Network Topologies

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Trade-offs



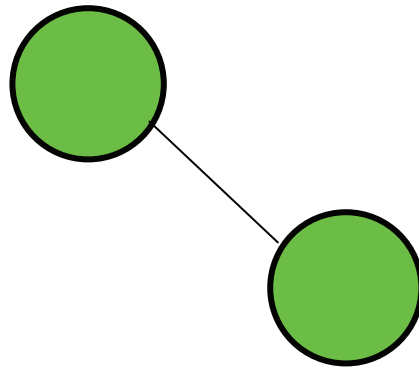
SpaceWire offers many new possibilities to choose the right balance between a number of parameters:

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

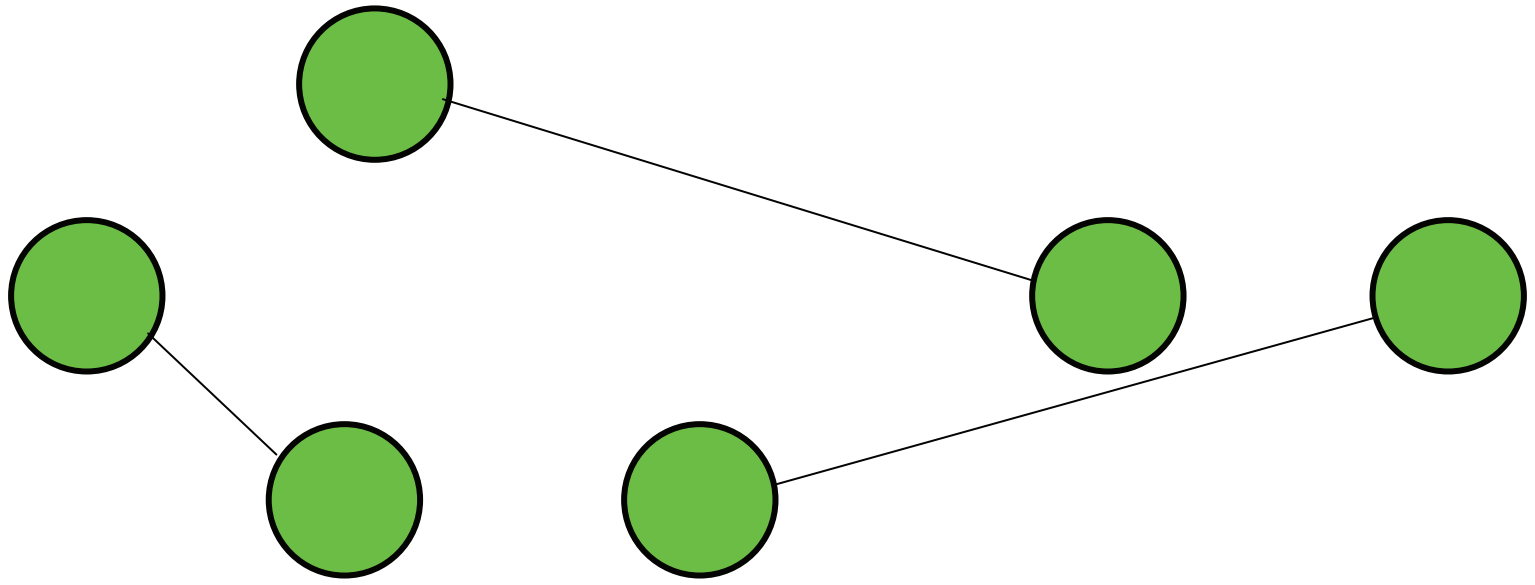
You have to make this choice

- **This paper may give some ideas to help you**

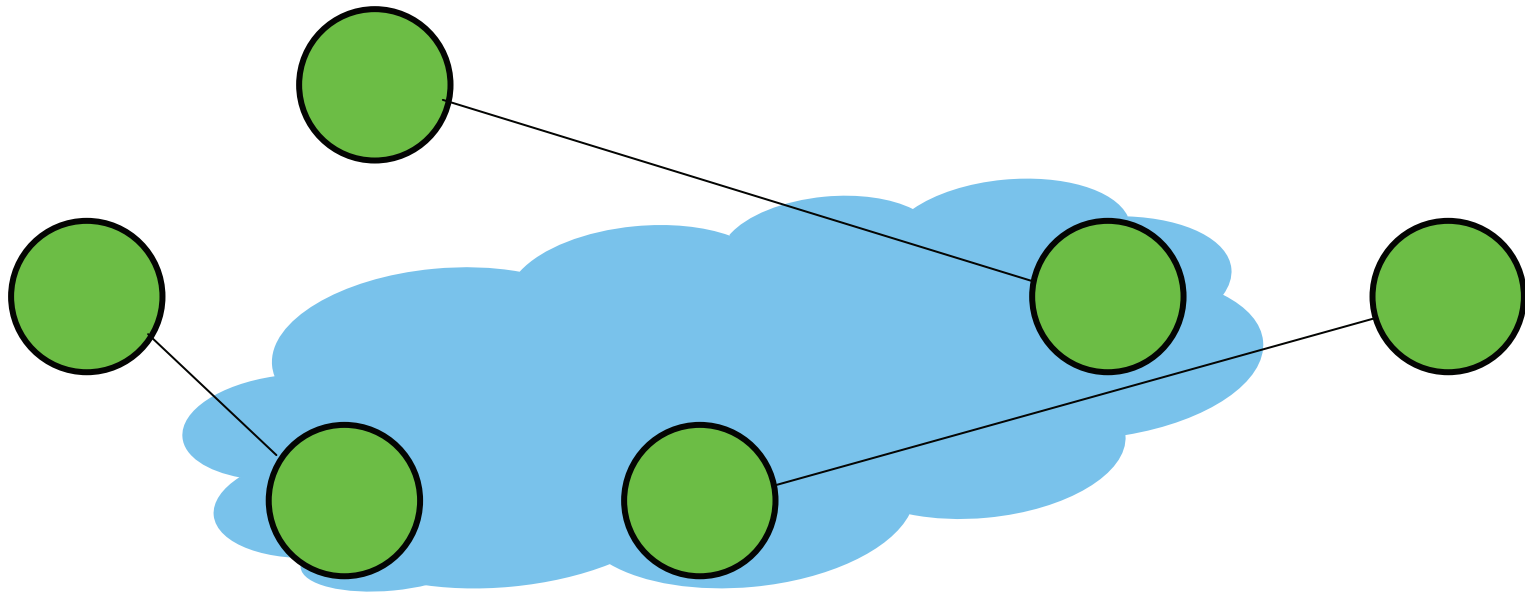
Point-to-point



Point-to-point, no Routing 4Links[®]

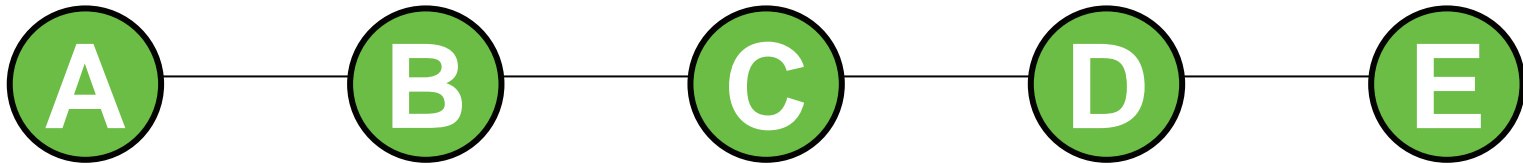


Non-SpaceWire cloud



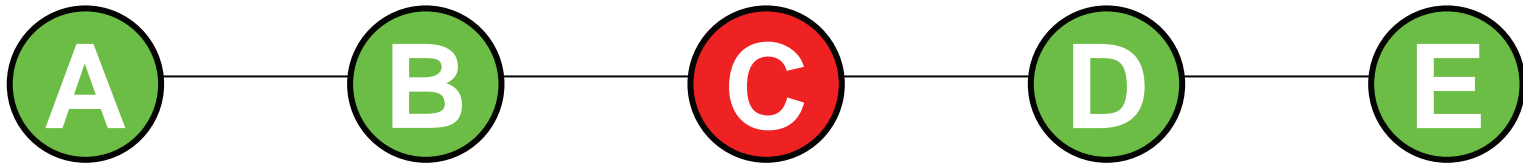
- **There actually is a network between the SpaceWire links**
- **But that network is not SpaceWire**

(Daisy-) Chain



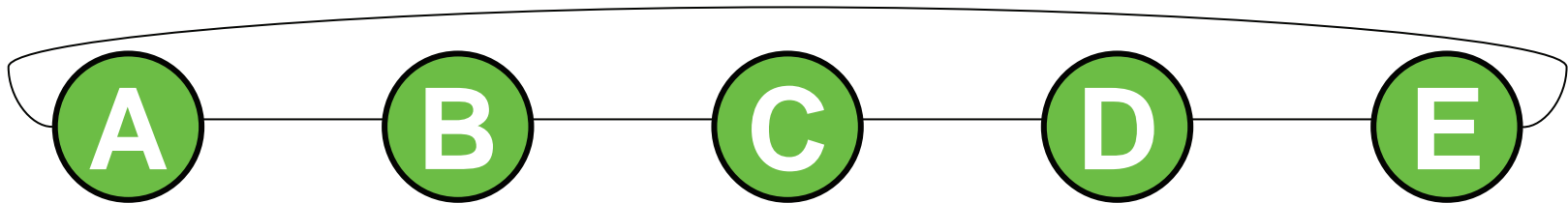
- **Simple, but requires a routing switch at each node**

(Daisy-) Chain



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

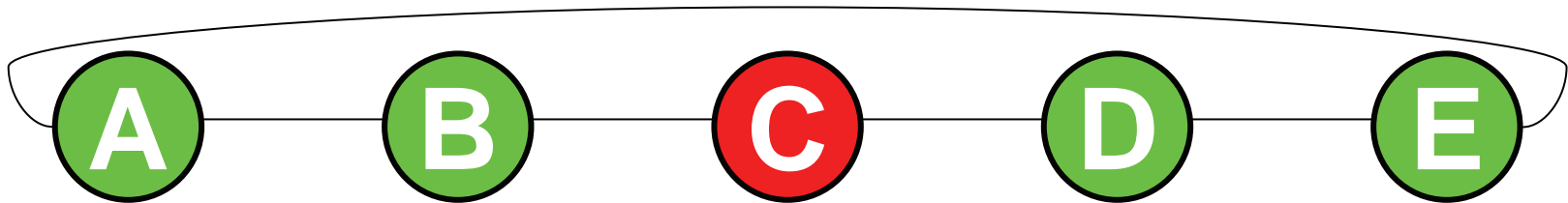
Ring



Looping the Chain to make a Ring

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

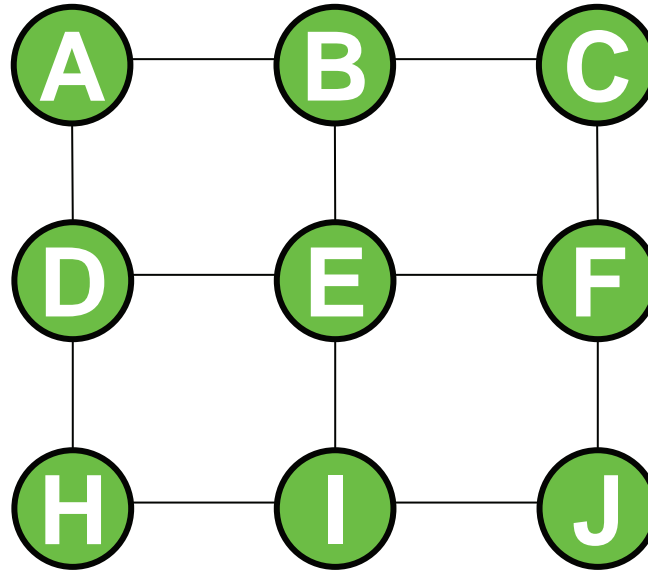
Ring



Looping the Chain to make a Ring

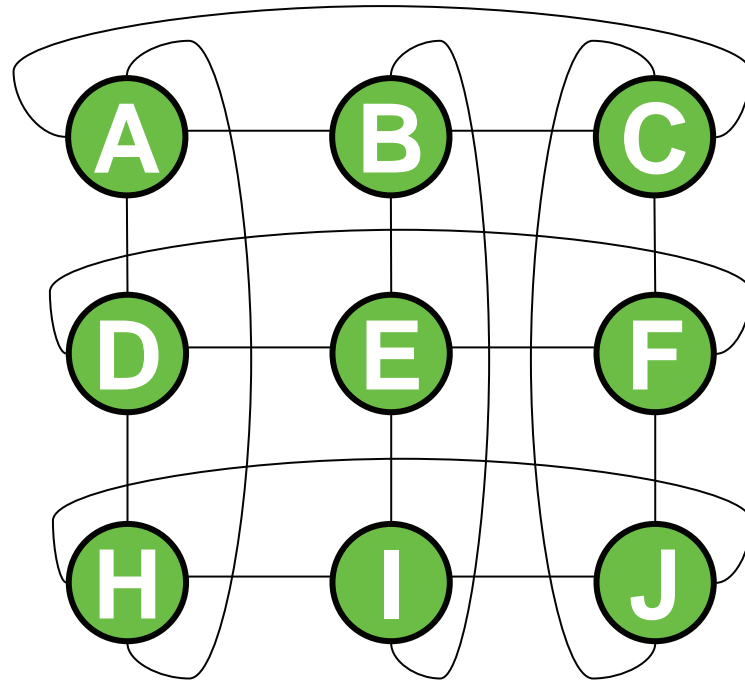
- Also removes the single points of failure
- D E A B is still a valid Chain if C fails

Grid: (Multi-dimensional Chain)



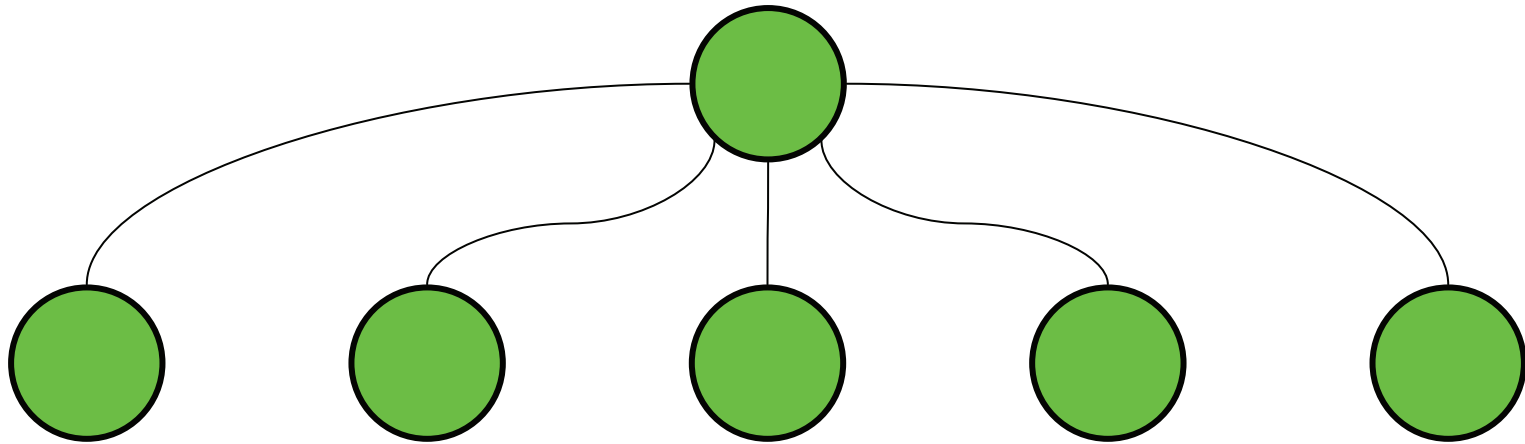
- **More ports per node**
- **Further reduces number of hops**
- **Further improves fault-tolerance**

Toroid: Multi-dimensional Ring



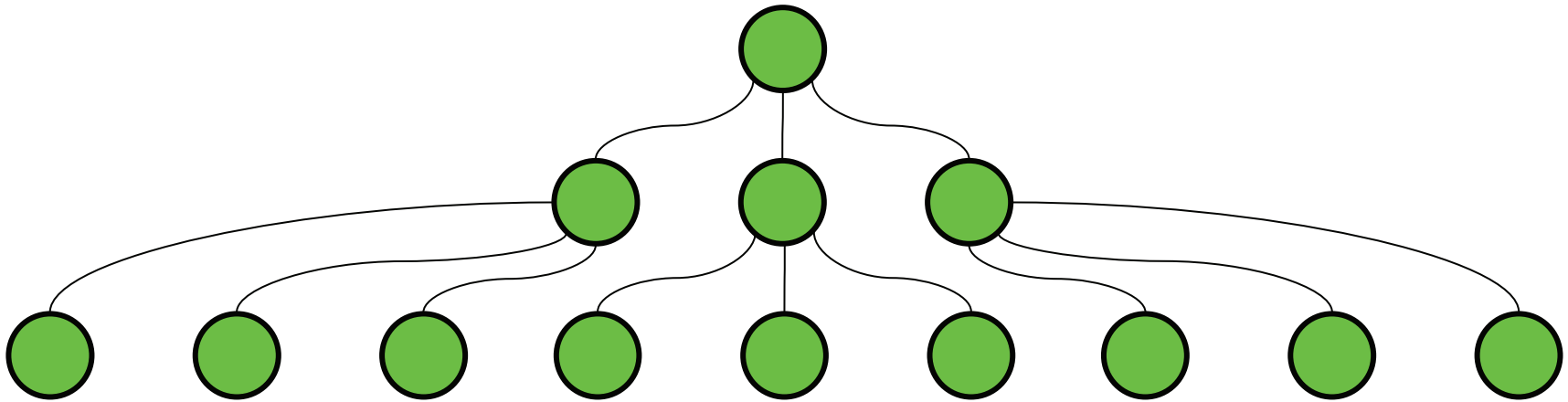
- **Still more ports per node**
- **Still further reduces number of hops**
- **Still further improves fault-tolerance**

Tree: Central Routing Switch / Concentrator



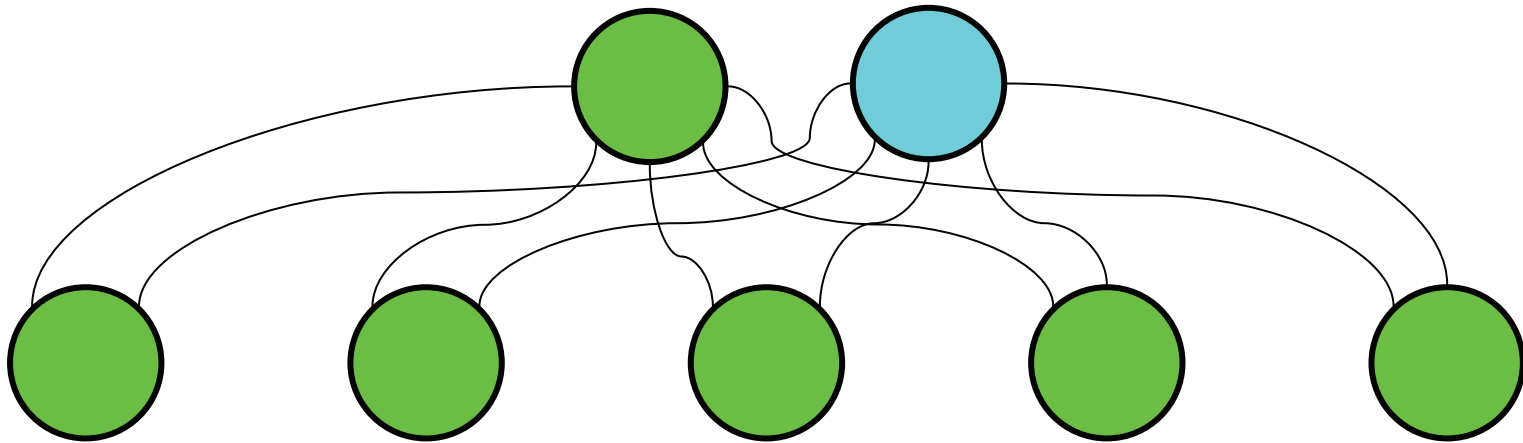
- **Simple distinction between nodes and routing switches or concentrators**

Tree: Central Routing Switch with Concentrators



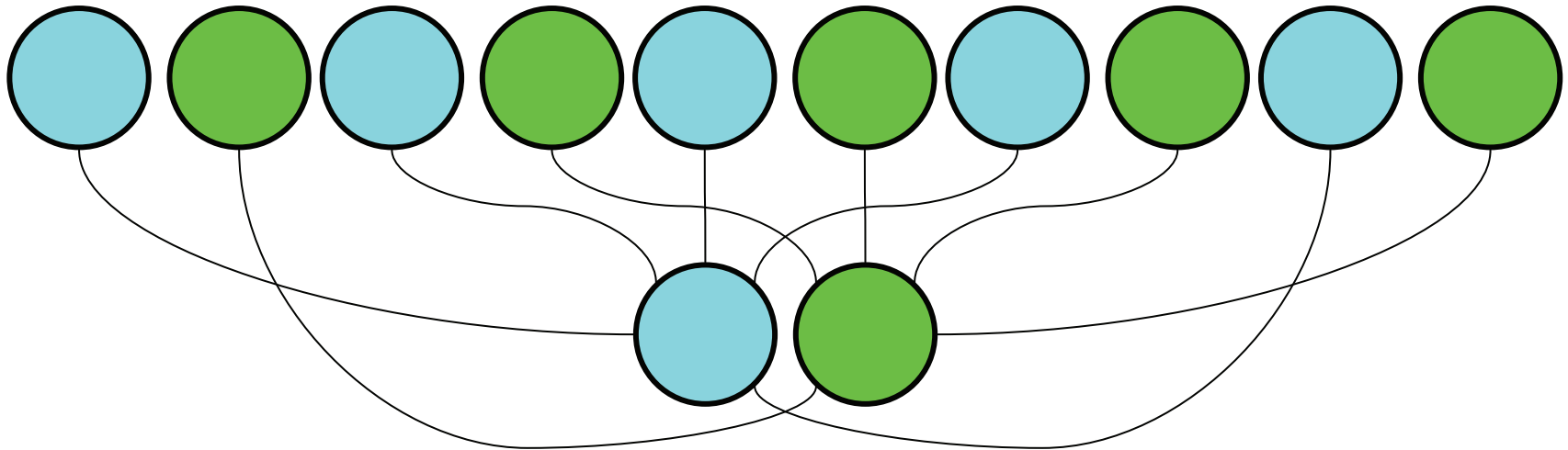
- Can be good if most traffic is to/from the root
- Root can be bottleneck if nodes need to communicate with each other
- Not fault-tolerant

Tree: Redundant Central Routing Switch



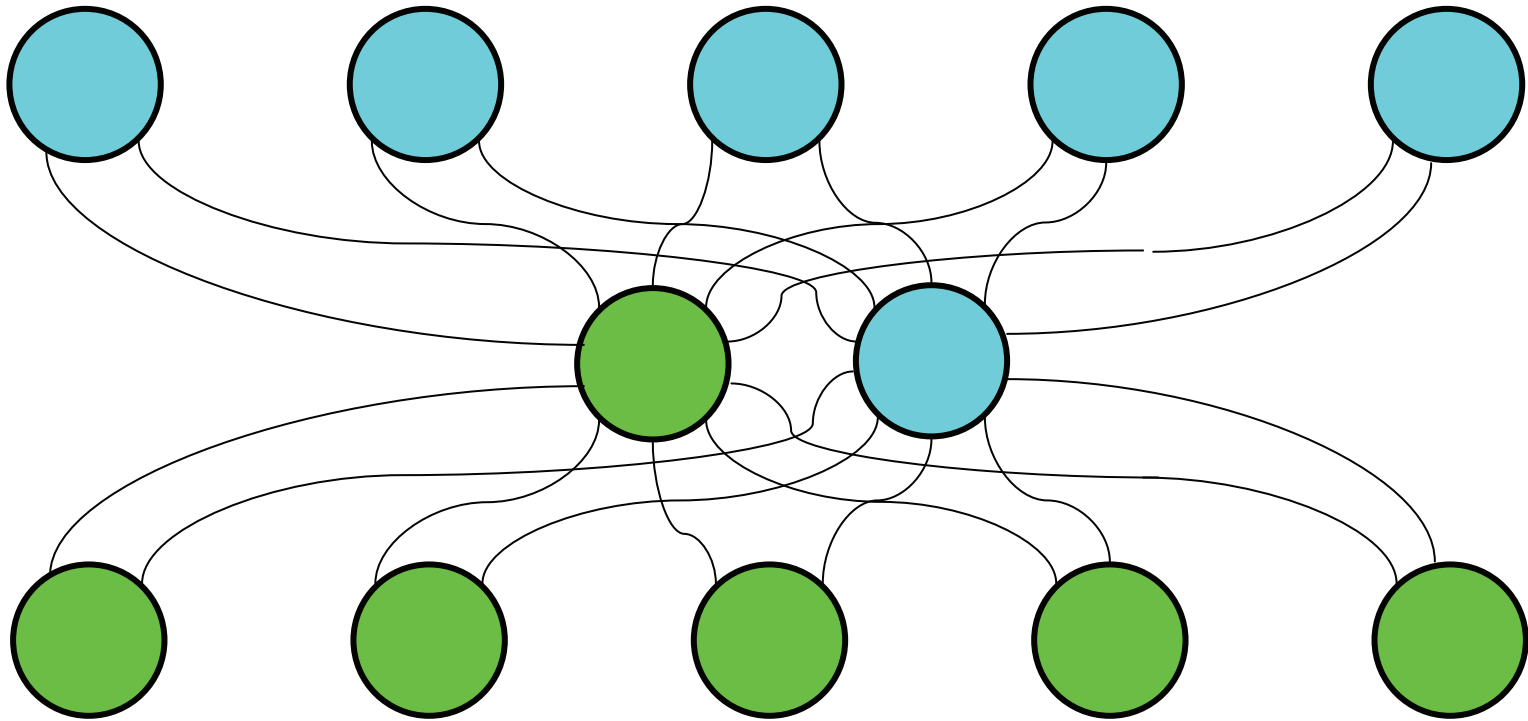
- **Starts to add lots of cables**

Cold Redundant System



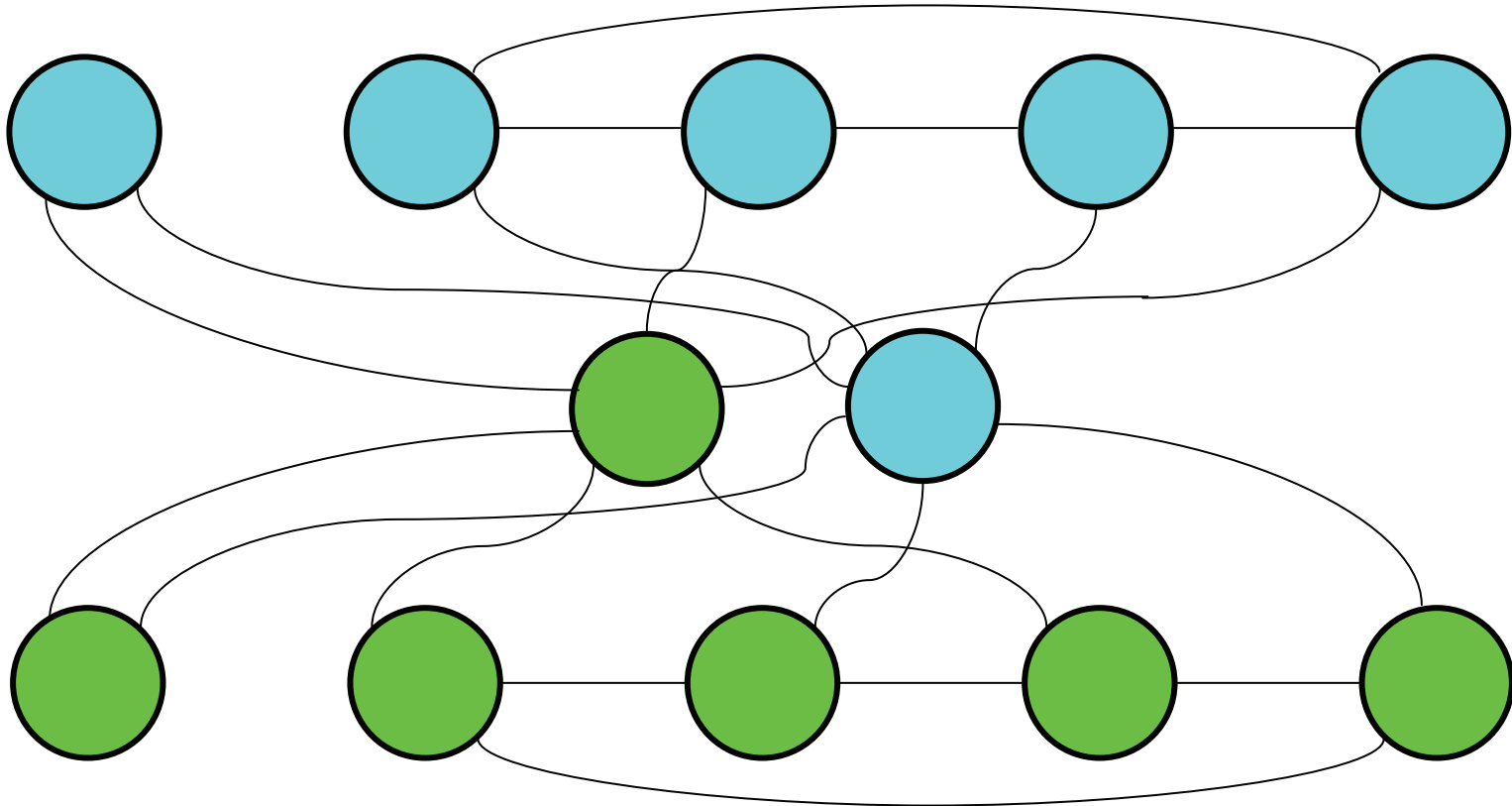
- **Either Nominal system in use**
- **Or Redundant system in use**
- **Not part Nominal part Redundant**

Cold Redundant System



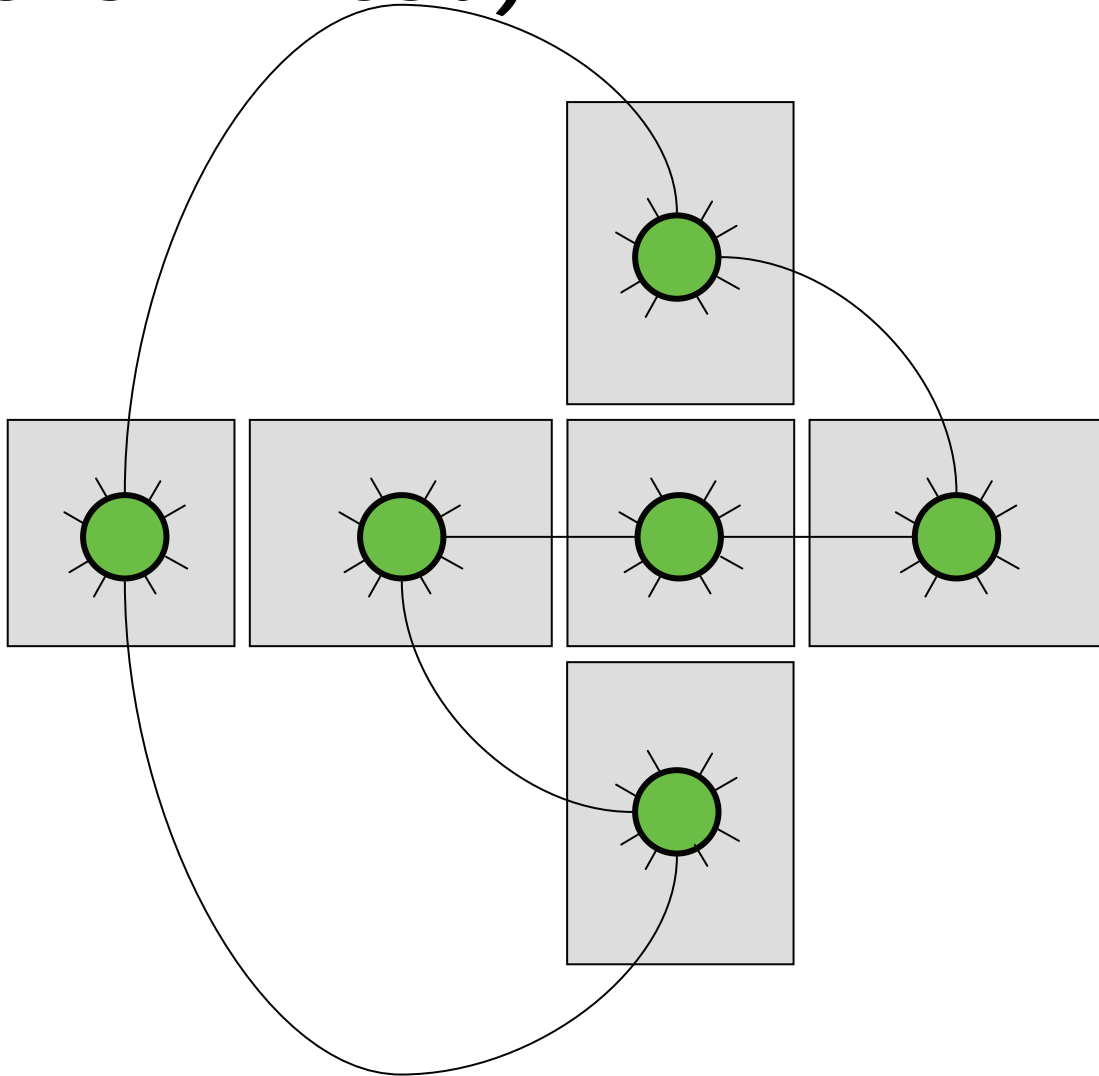
- **More cables**
- **But can use some Nominal and some Redundant nodes with either switch**

Hybrid Cold Redundant

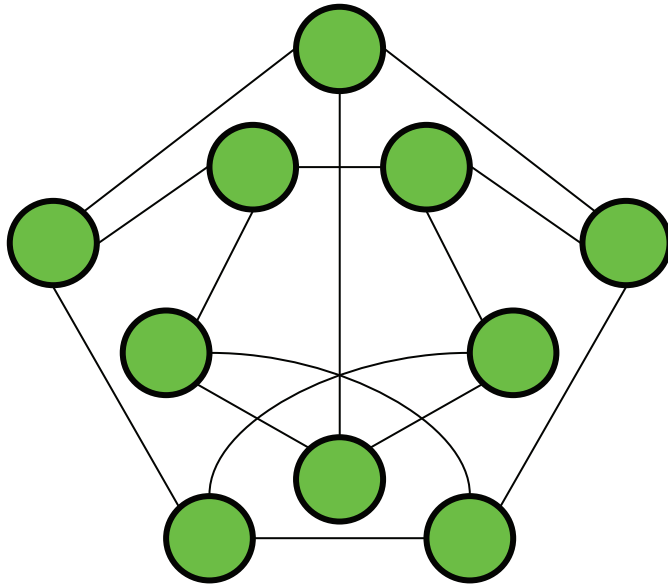


- **Same number of cables**
- **Possibly shorter cables in ring**
- **Fewer ports needed in central routing switches**

Hybrid topology (notional PnPSat)

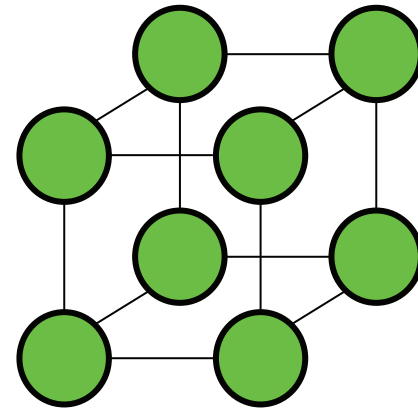


Further Study: Graph Theory 4Links



Petersen Graph

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



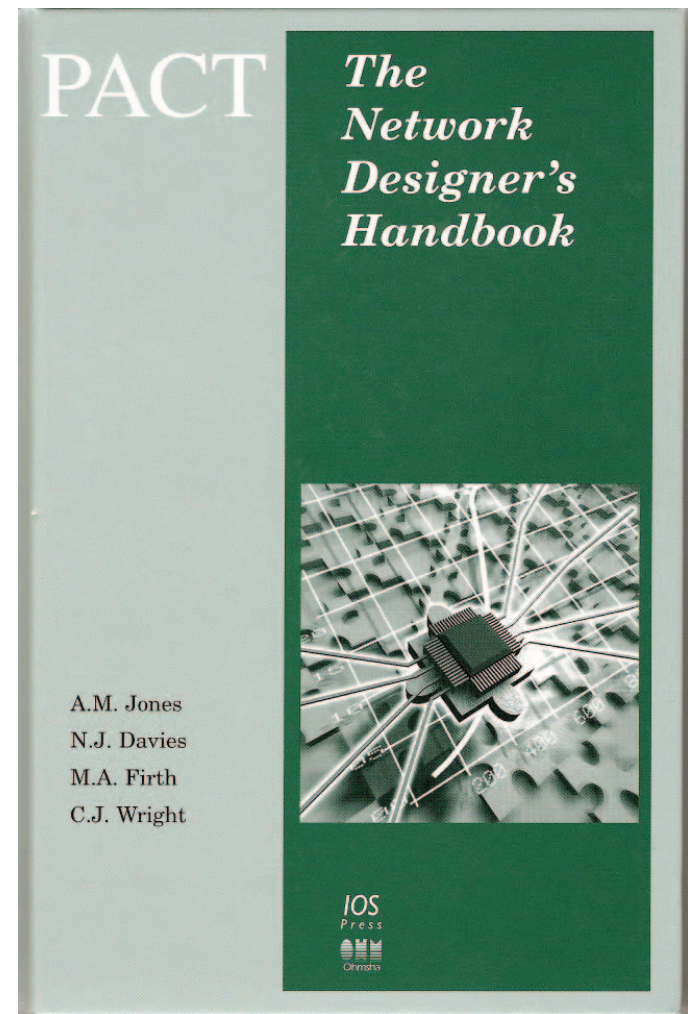
Cube

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

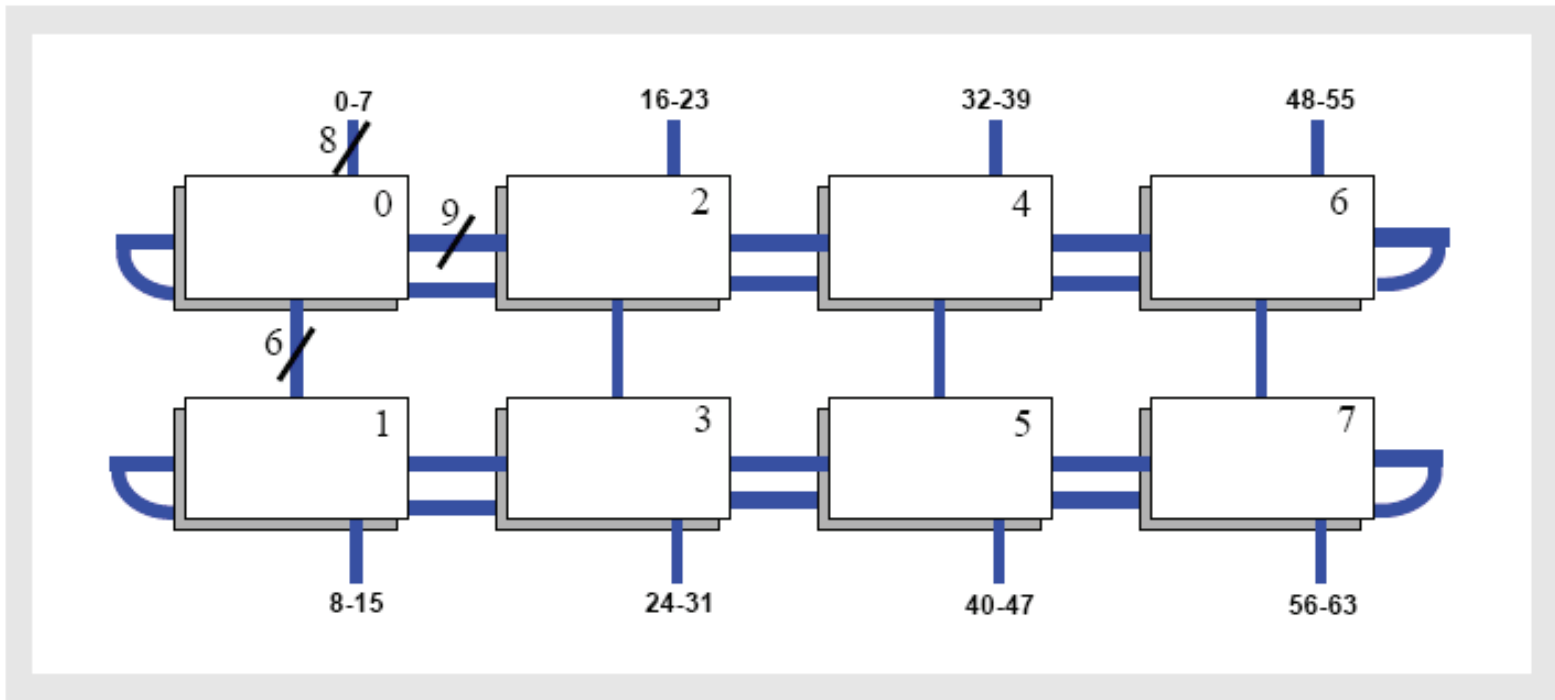
Further Study: Network Designer's Handbook

- **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**

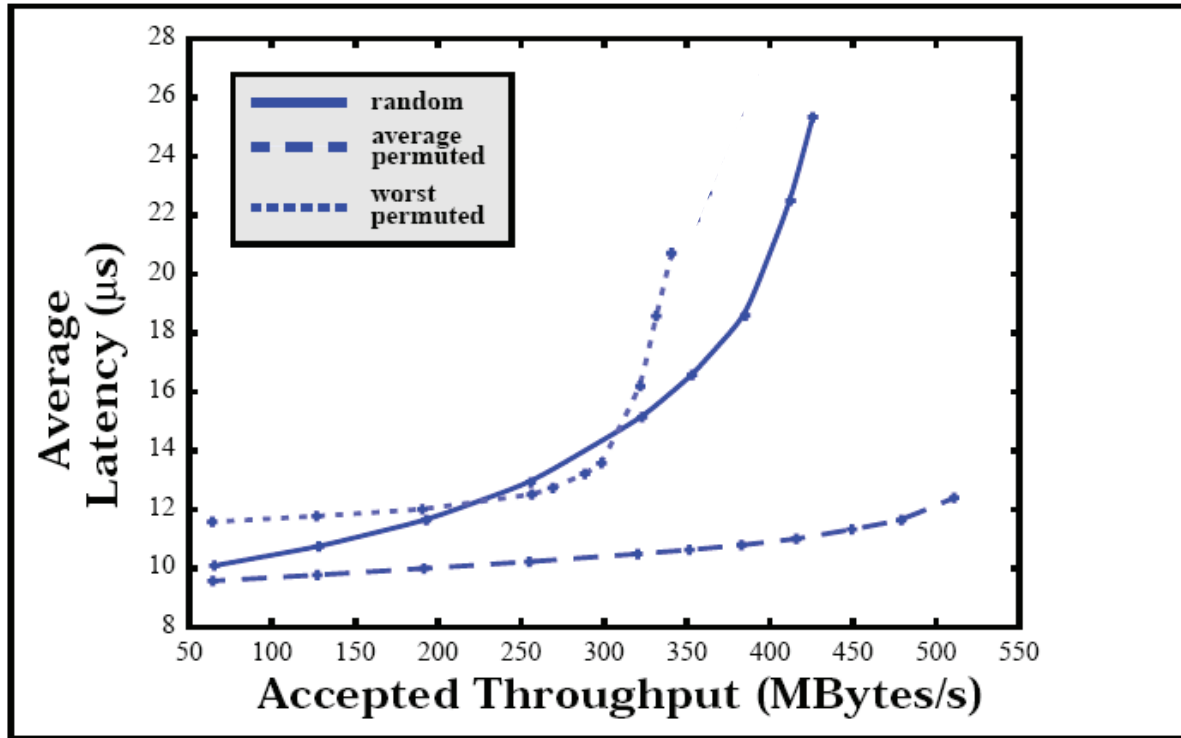


Further Study: Network Designer's Handbook



- **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 from 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**