4Links™

Building SpaceWire Systems

ISWS 2003, ESTEC

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4Links Limited

www.4Links.co.uk

Outline of presentation

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1. Topological Freedom
2. The Bus Problem
3. A Better RS232/422 Serial Port
4. Less complexity with Small Routers
5. Scalable systems with Large Routers
6. Examples with the 4Links Demo System
7. Modularity, Re-use, Time-Codes, FDIR
8. Rad-Hard by System Design

The Bus Problem

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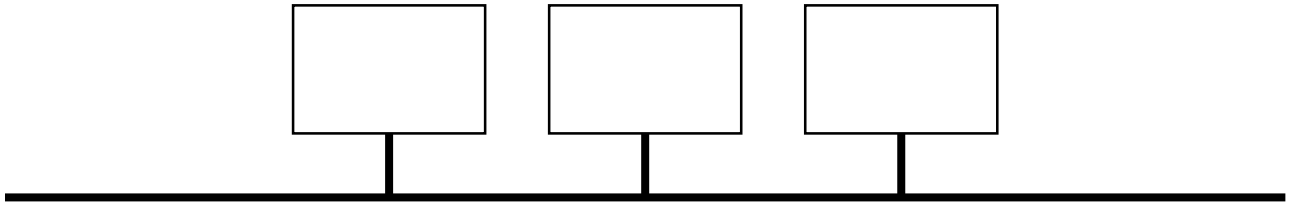

- **3 nodes: Bandwidth per node = X/3**

The Bus Problem

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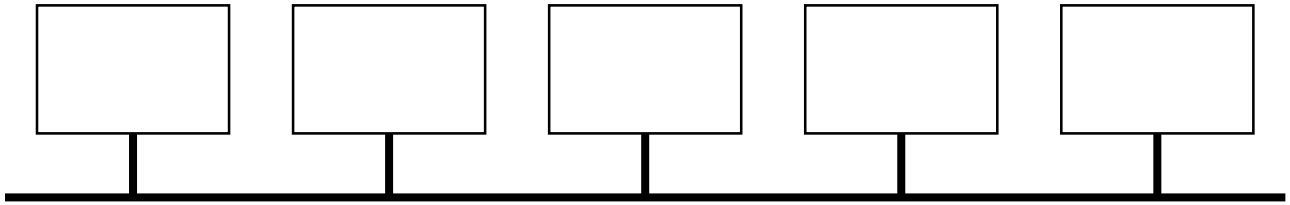

- 3 nodes: Bandwidth per node = X/3
- **5 nodes: Need X/3 per node**
  Only get X/5 per node

The Bus Problem

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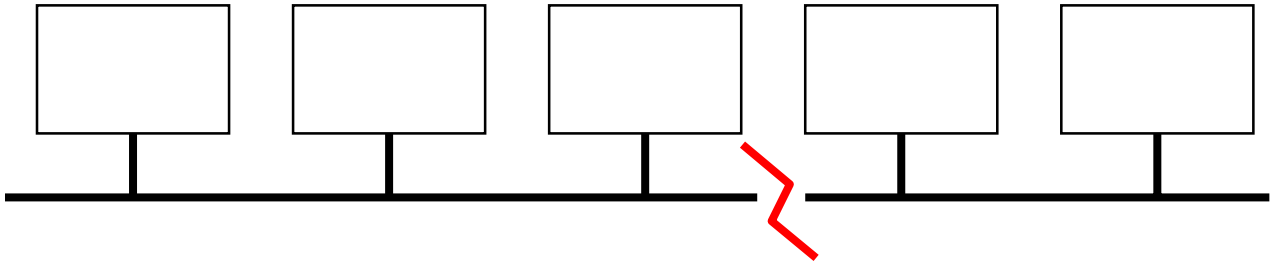

- 3 nodes: Bandwidth per node = X/3
- 5 nodes: Need X/3 per node
  Only get X/5 per node
- **Bus is single point of failure**

Cross-strapping with point-to-point RS232/422

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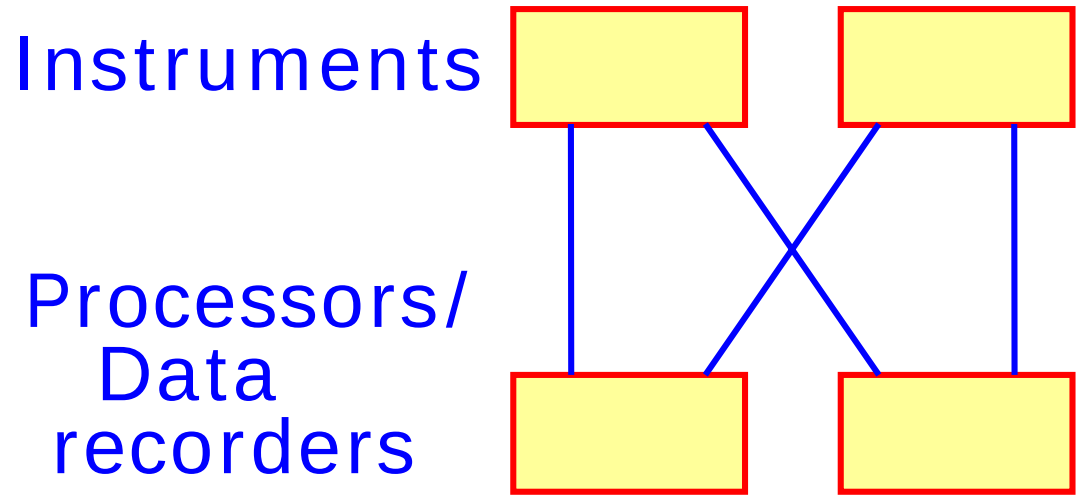

- **2 Instruments: 4 Connections**

Cross-strapping with point-to-point RS232/422

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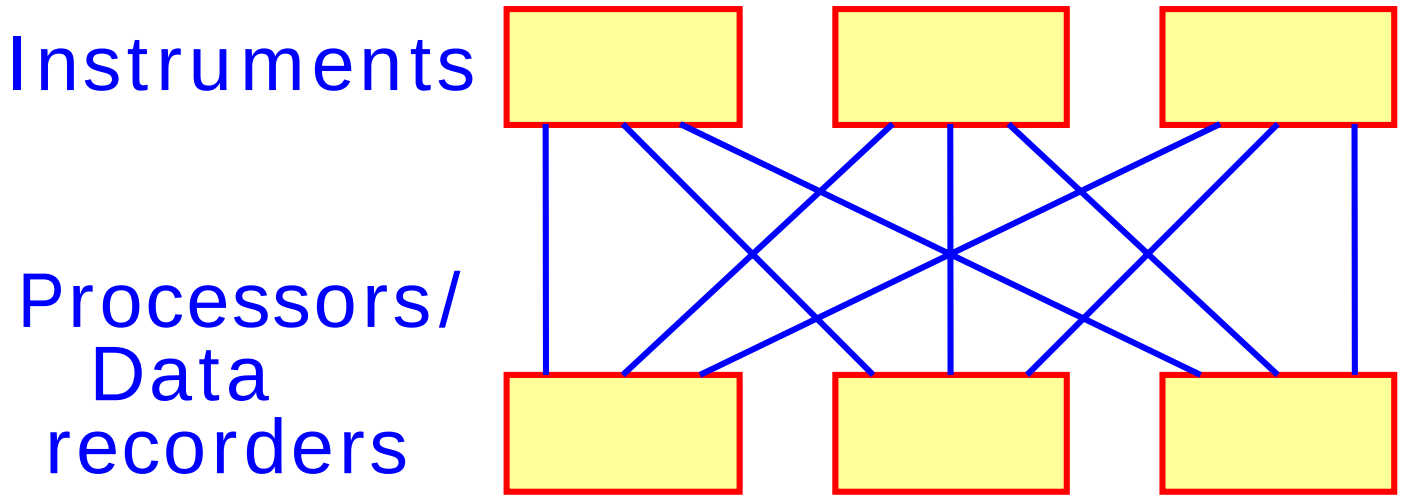

- 2 Instruments: 4 Connections
- **3 Instruments : 9 Connections**

Cross-strapping with point-to-point RS232/422

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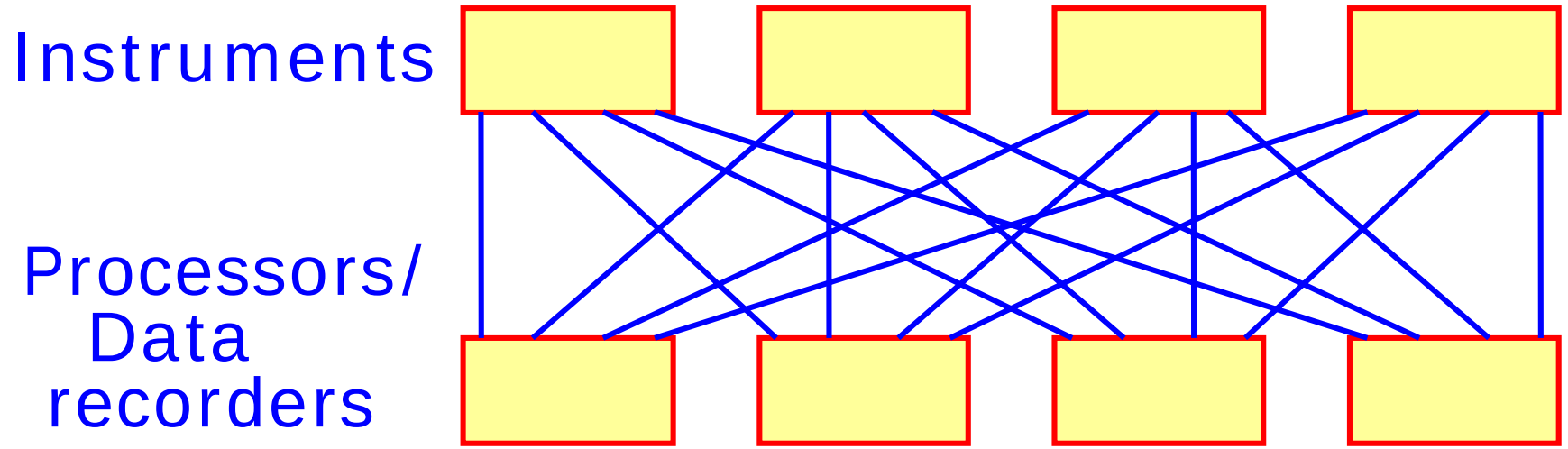

- **2 Instruments: 4 Connections**
- **3 Instruments : 9 Connections**
- **4 Instruments : 16 Connections**

Cross-strapping with point-to-point RS232/422

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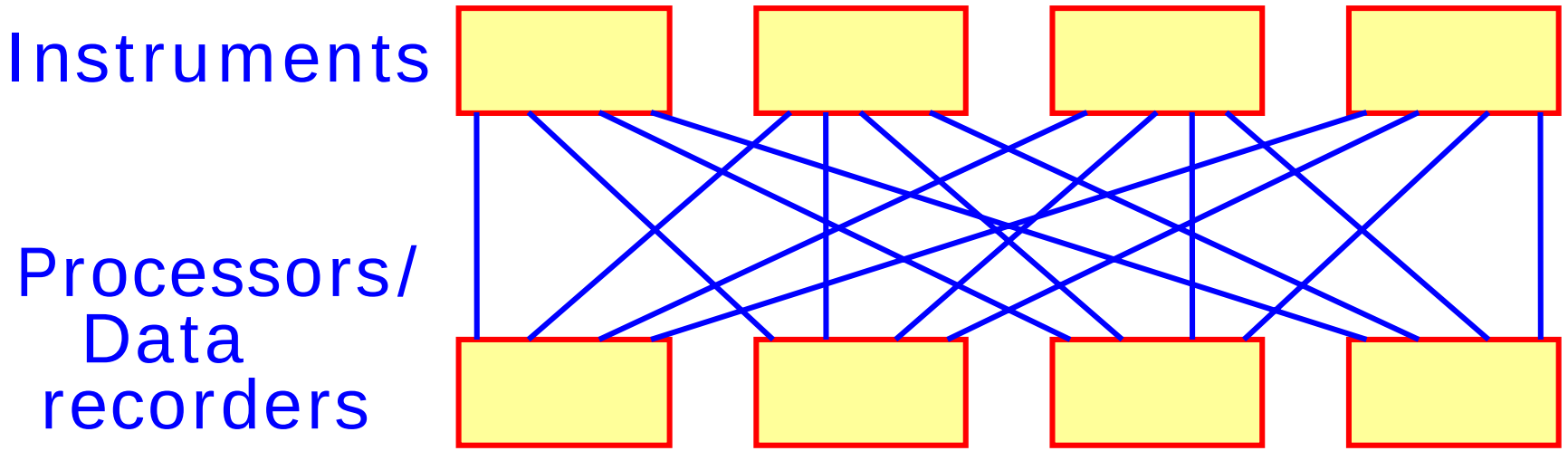

- **2 Instruments: 4 Connections**
- **3 Instruments : 9 Connections**
- **4 Instruments : 16 Connections**
- **Connections = (No. of Instruments) squared**

Rings with small routers

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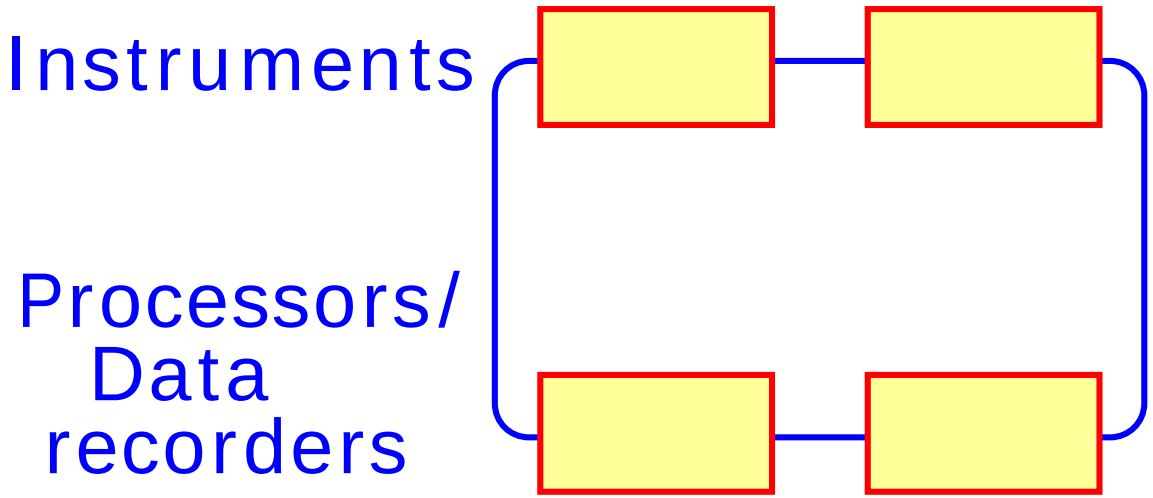

- **2 Instruments: 4 Connections (was 4)**

Rings with small routers

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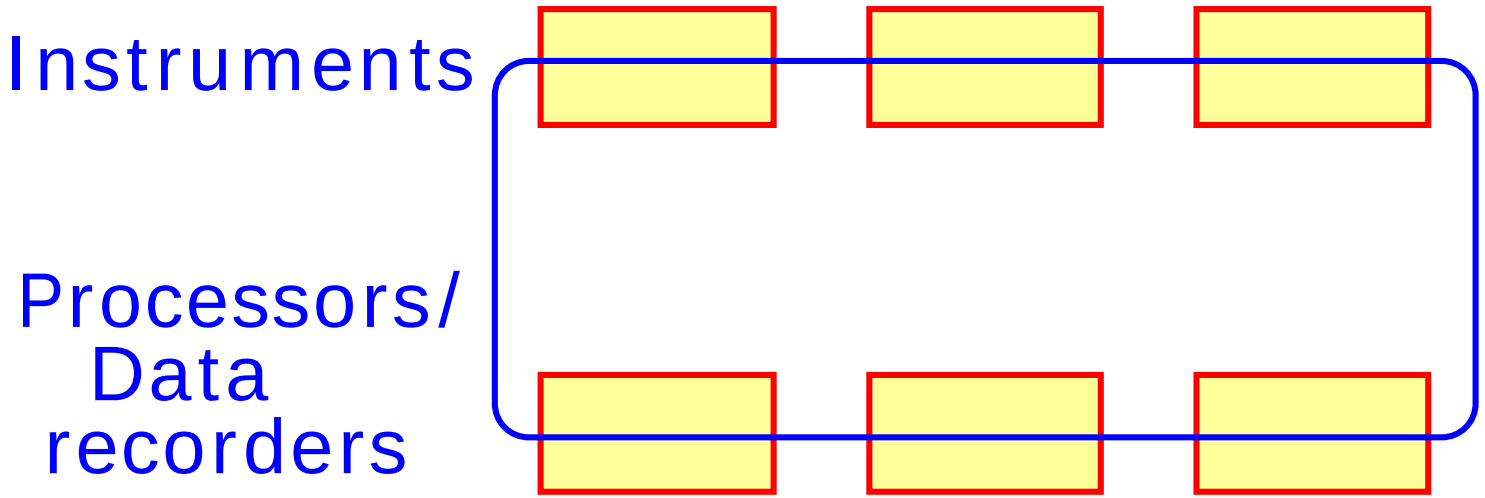

- 2 Instruments: 4 Connections
- **3 Instruments : 6 Connections (was 9)**

Rings with small routers

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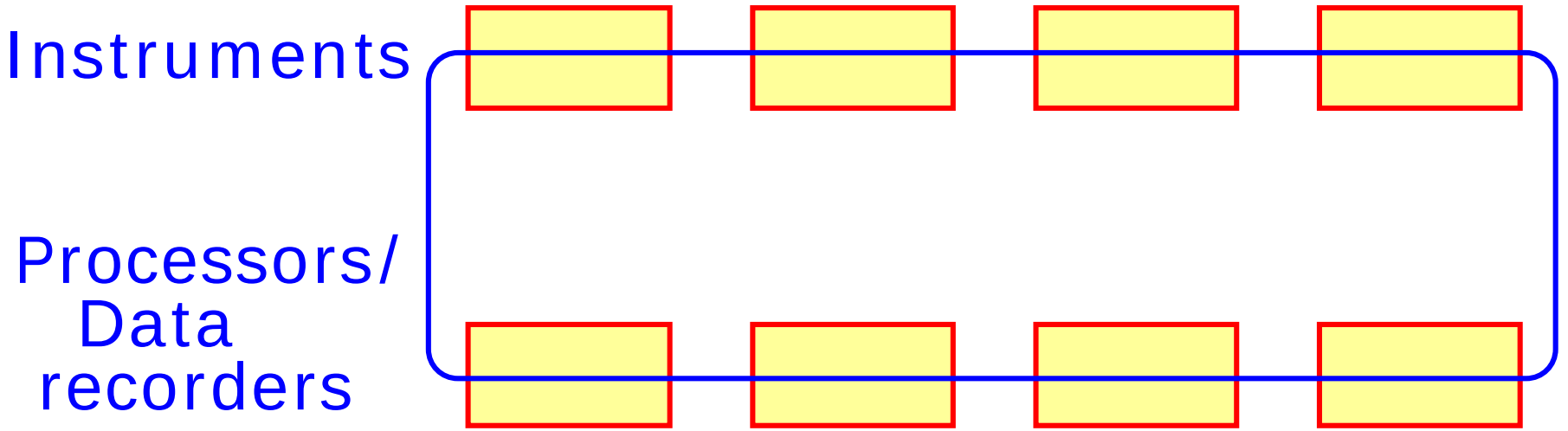

- **2 Instruments: 4 Connections**
- **3 Instruments : 6 Connections**
- **4 Instruments : 8 Connections (was 16)**

Rings with small routers

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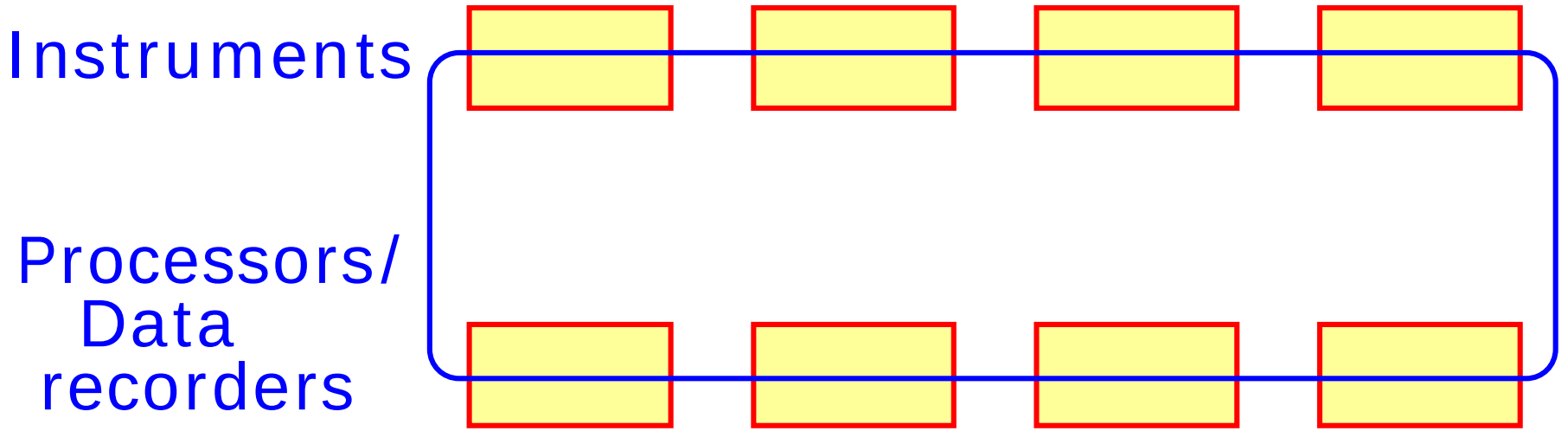

- 2 Instruments: 4 Connections
- 3 Instruments : 6 Connections
- 4 Instruments : 8 Connections (was 16)
- **Connections = Twice (Number of Instruments)**

Routers with Three Links

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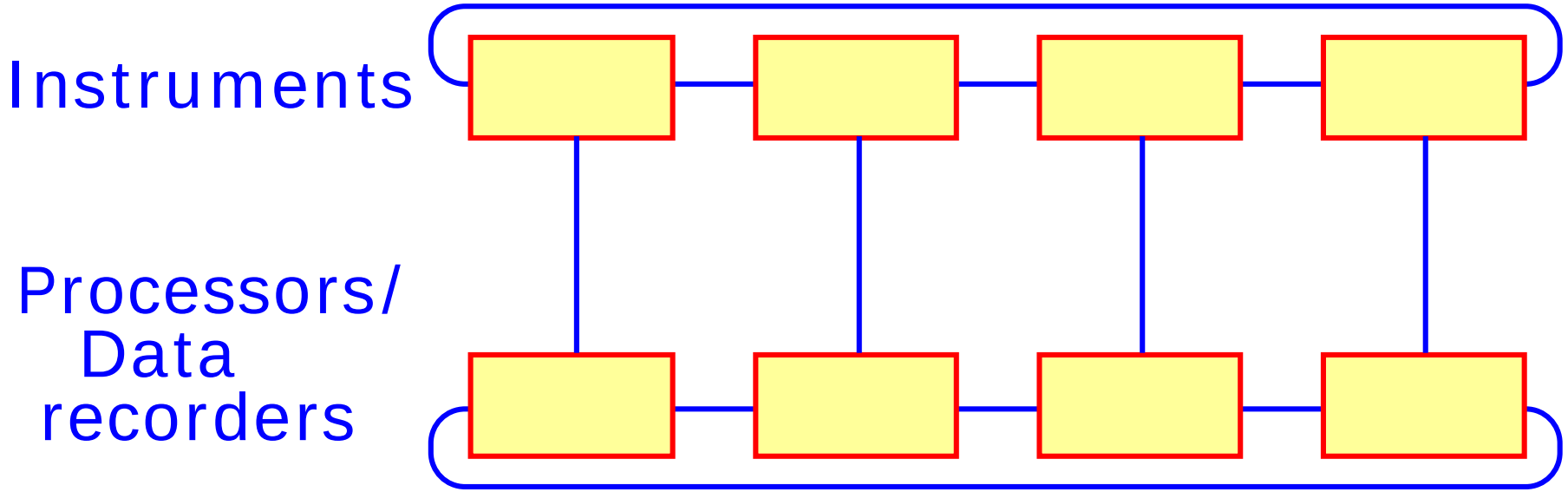

- **With three links per node, system can be tolerant of two faults**

Fully scalable systems with Multi-port Routers

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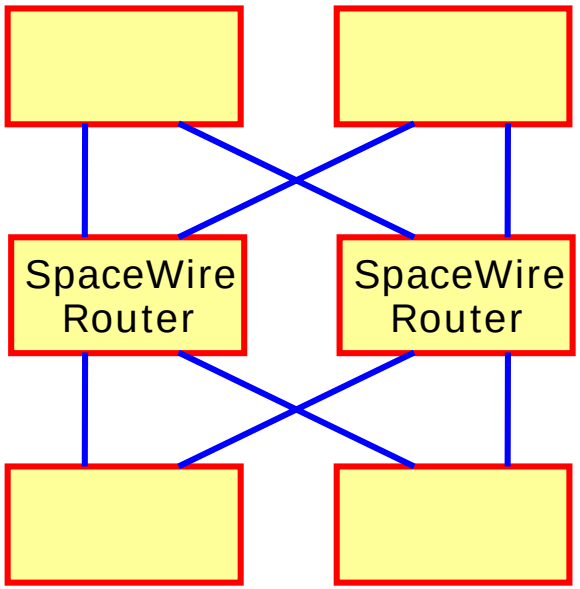
Instruments

Processors/ Data recorders



- **2 Instruments: 8 Connections**

Fully scalable systems with Multi-port Routers

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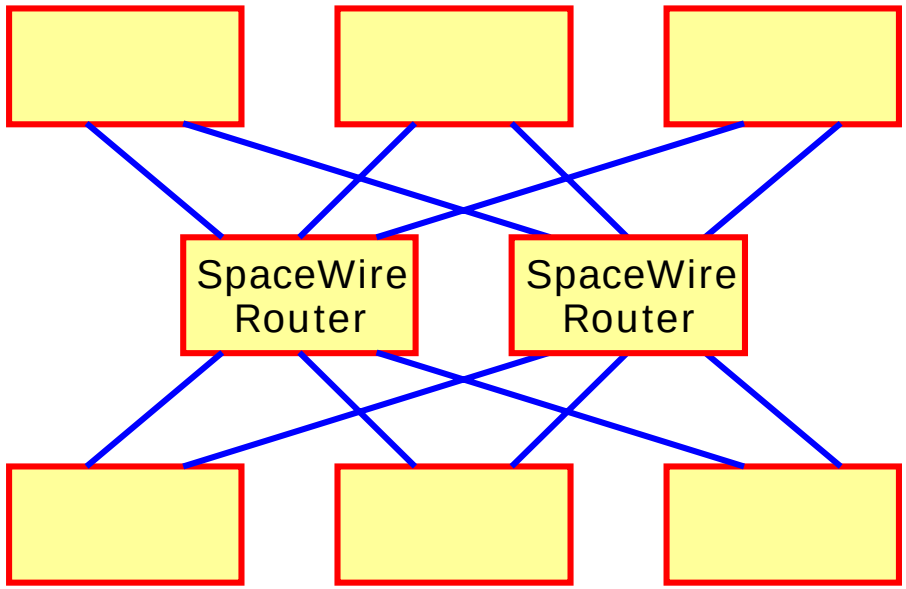
Instruments

Processors/ Data recorders



- 2 Instruments: 8 Connections
- **3 Instruments : 12 Connections**

Fully scalable systems with Multi-port Routers

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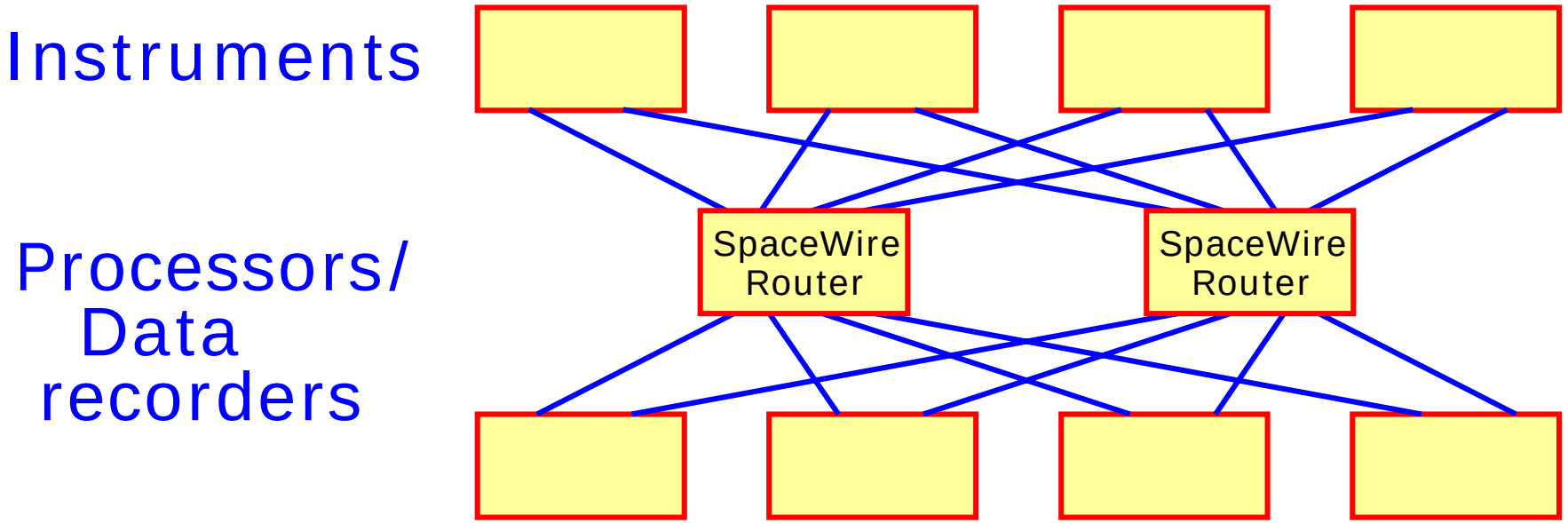

- **2 Instruments: 8 Connections**
- **3 Instruments : 12 Connections**
- **4 Instruments : 16 Connections (was 16)**

Fully scalable systems with Multi-port Routers

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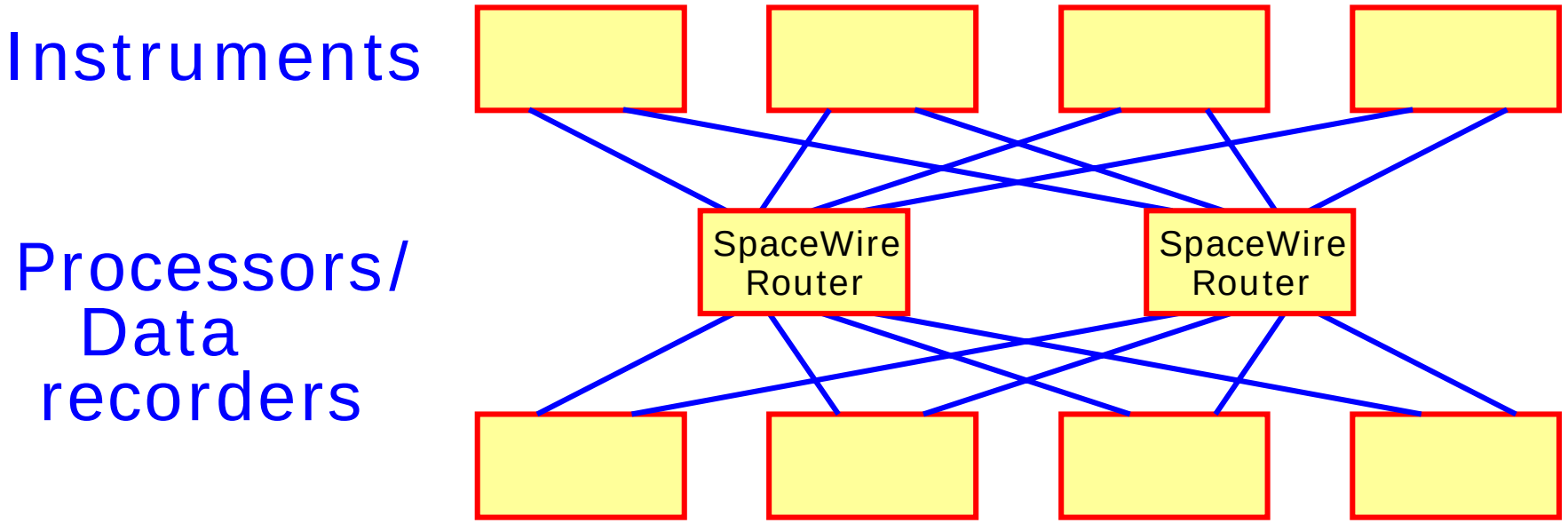

- 2 Instruments: 8 Connections
- 3 Instruments : 12 Connections
- 4 Instruments : 16 Connections
- **Connections = 4 * (Number of Instruments)**

Rings and Routers

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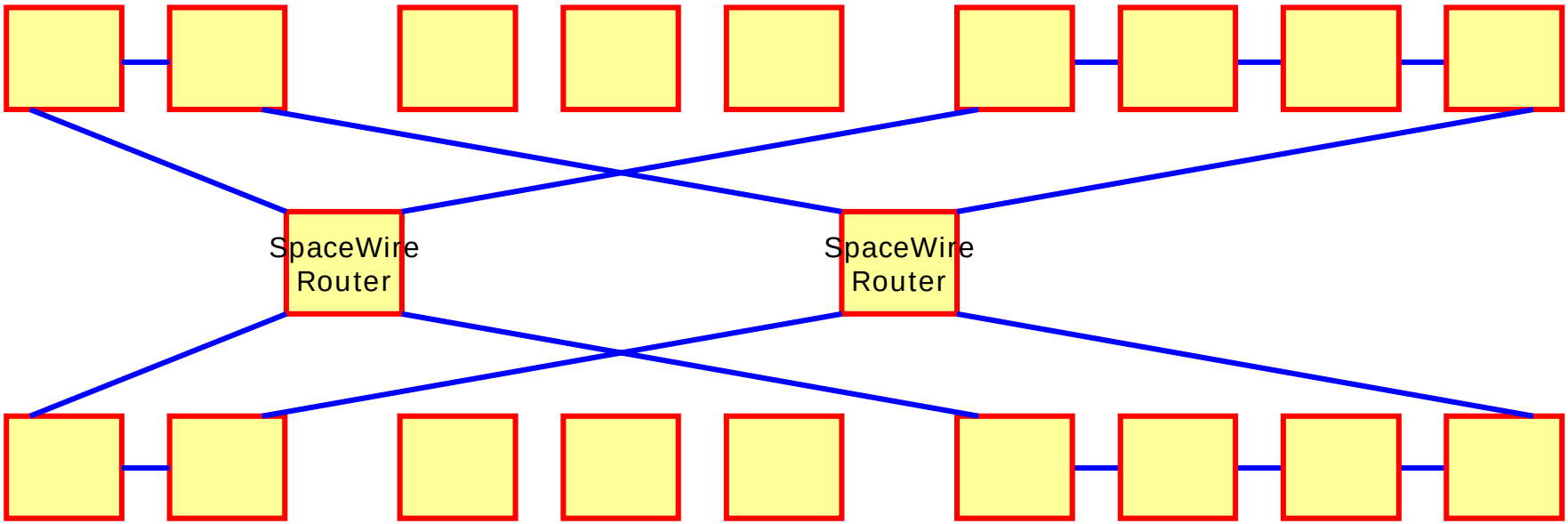

- **Rings via Routers**

Rings and Routers

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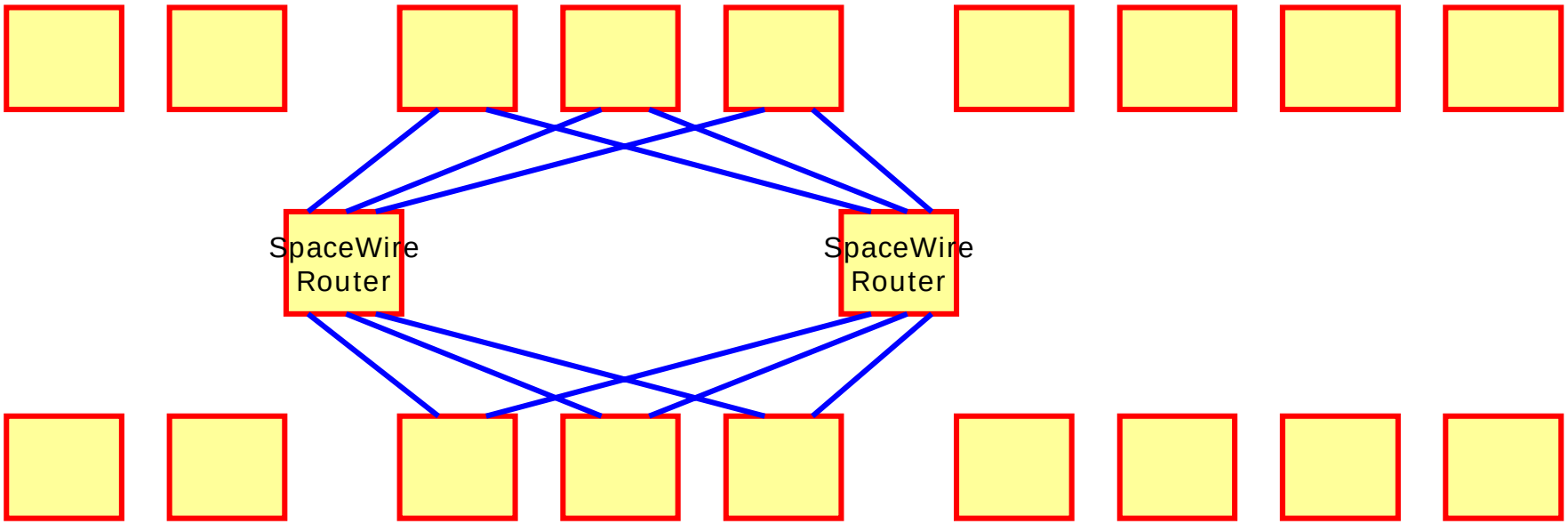

- Ring via Routers
- **Nodes directly connected to Routers**

Rings and Routers

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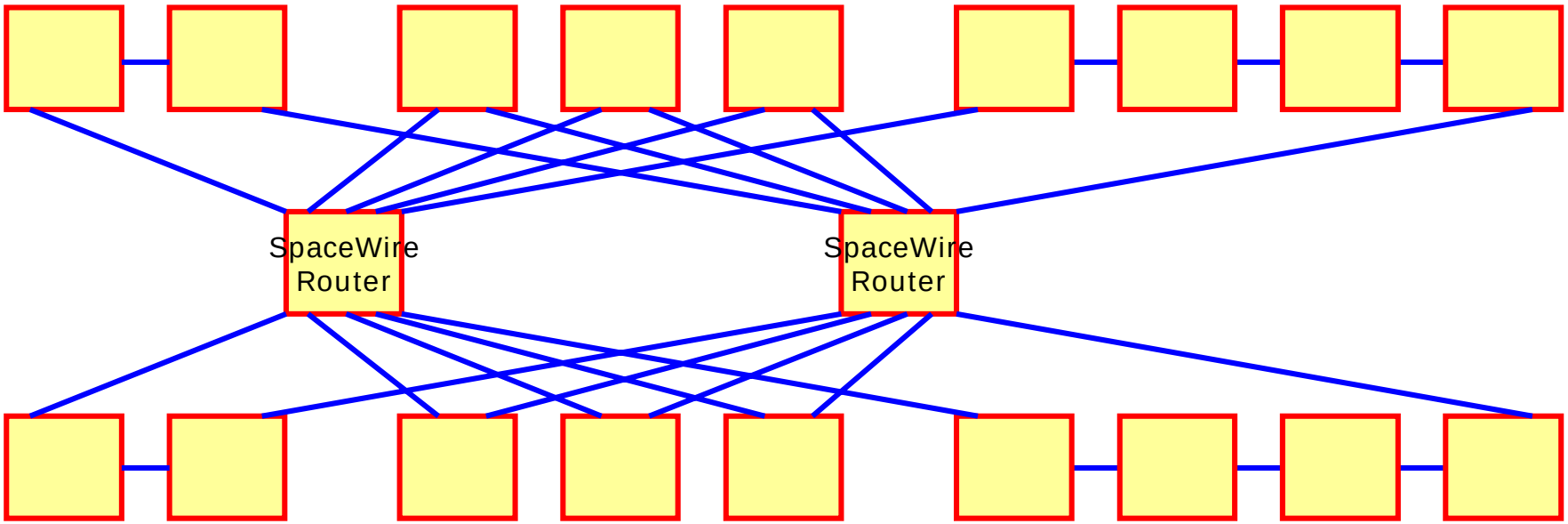

- Ring via Routers
- Nodes directly connected to Routers
- **Bandwidth where needed**
- **No Single Point of Failure**

Examples with 4Links demonstration

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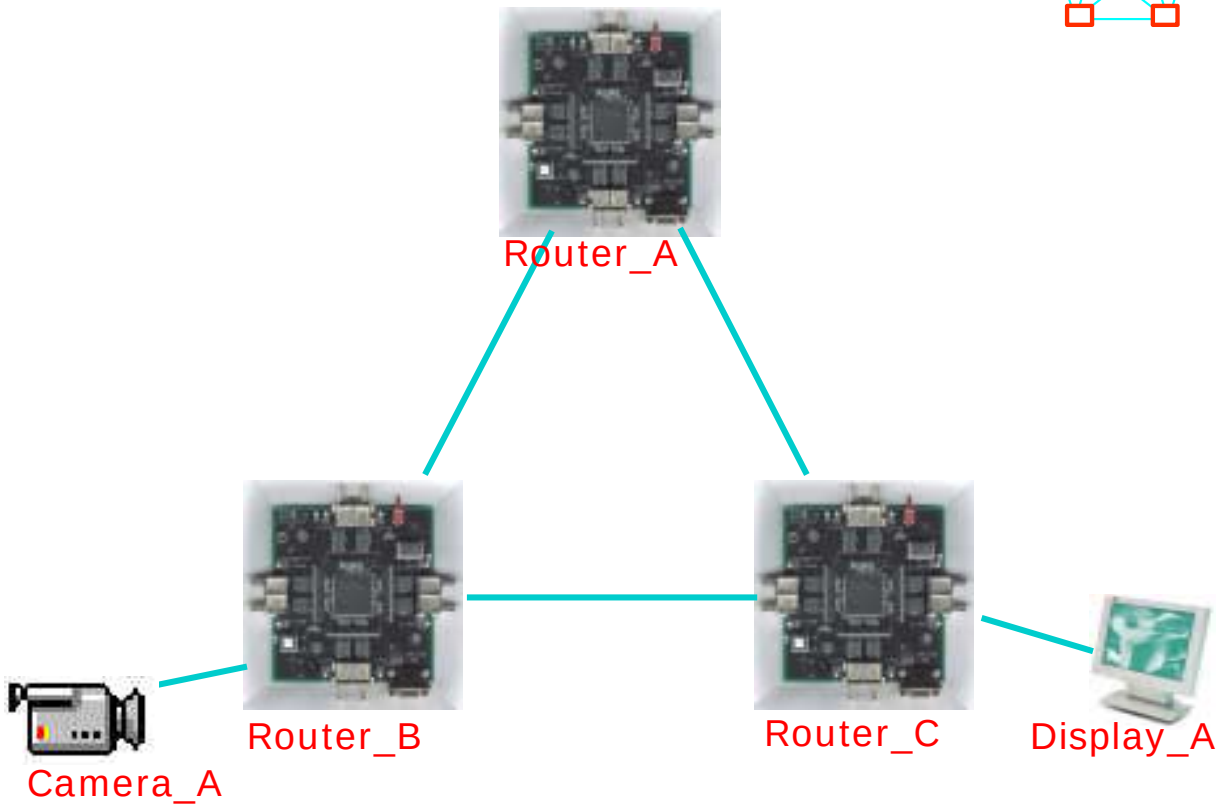

- **Uncompressed video, no frame buffer**
- **High bandwidth provided even by ring**
- **No Single Point of Failure**

Examples with 4Links demonstration

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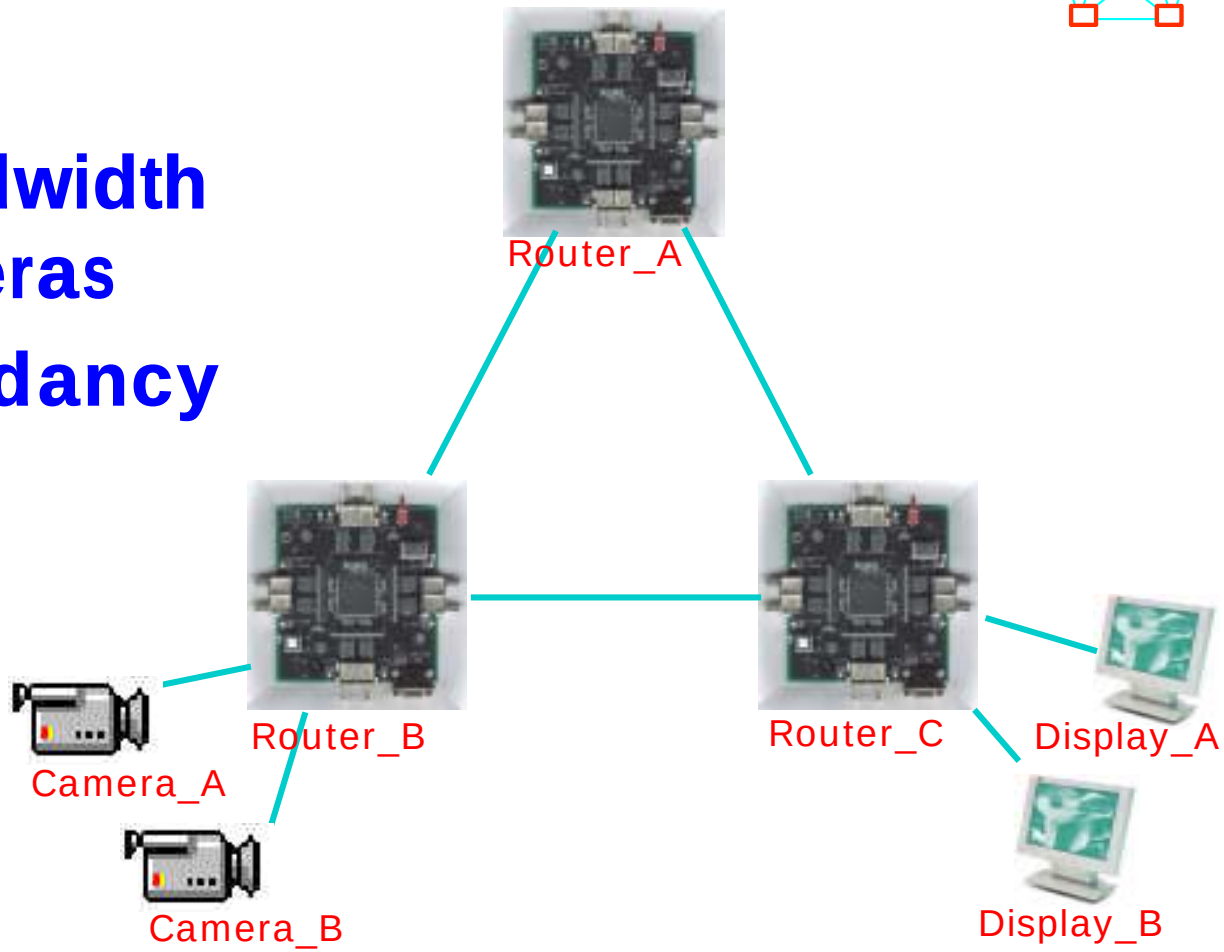
- **Enough bandwidth for two cameras**
- **But no redundancy**



Examples with 4Links demonstration

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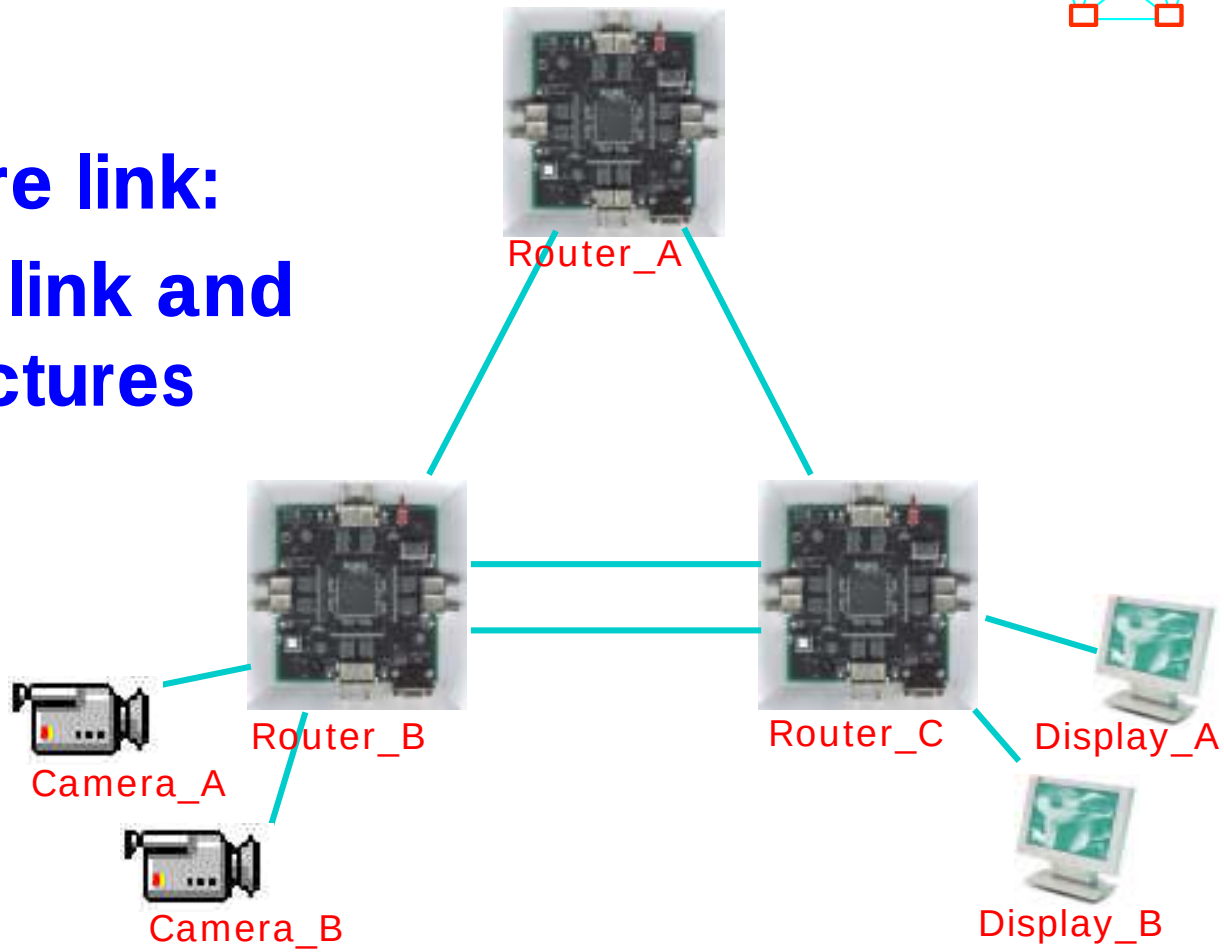
- **Add one more link:**
- **Remove any link and displayed pictures recover**



Examples with 4Links demonstration

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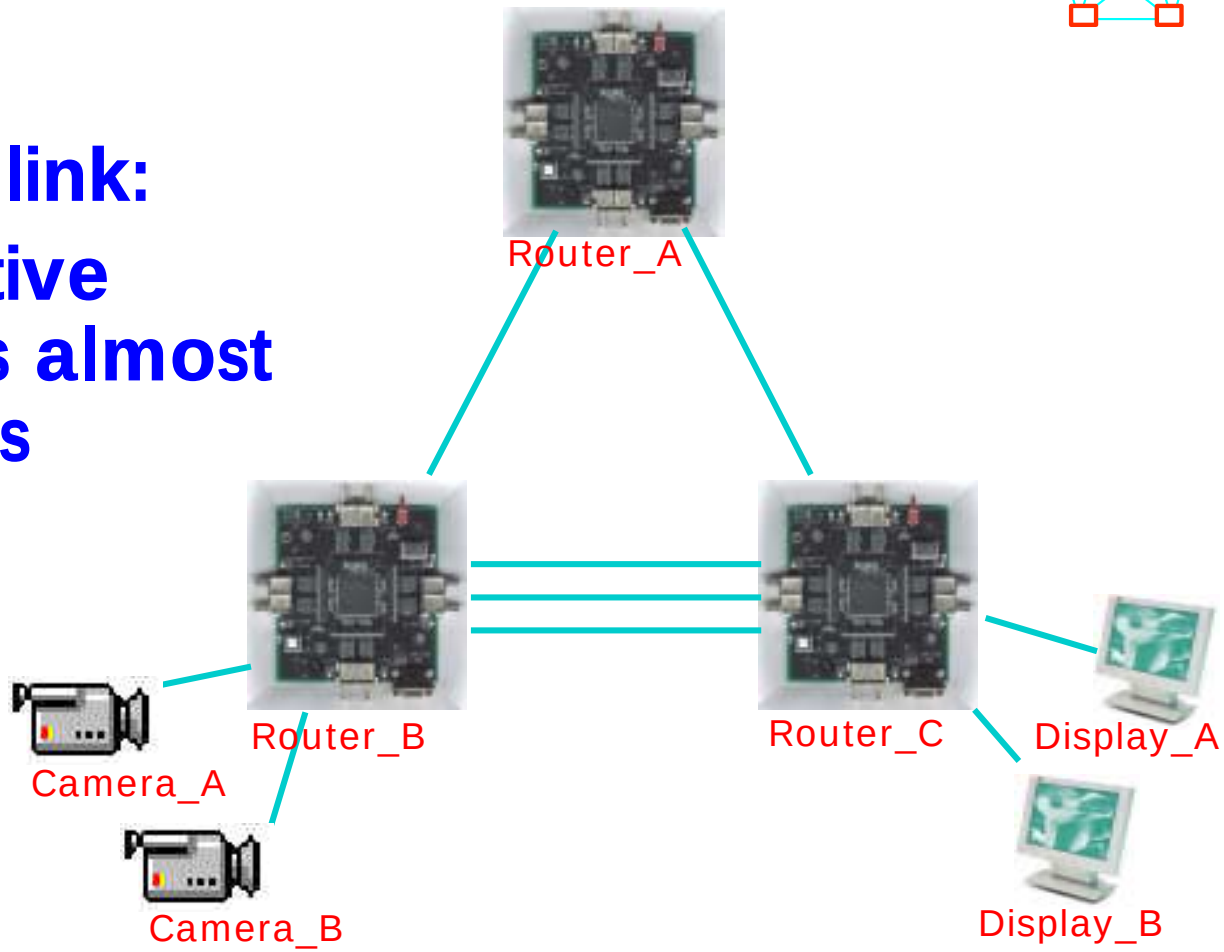
- **Add another link:**
- **Group Adaptive Routing gives almost instantaneous recovery**



Examples with 4Links demonstration

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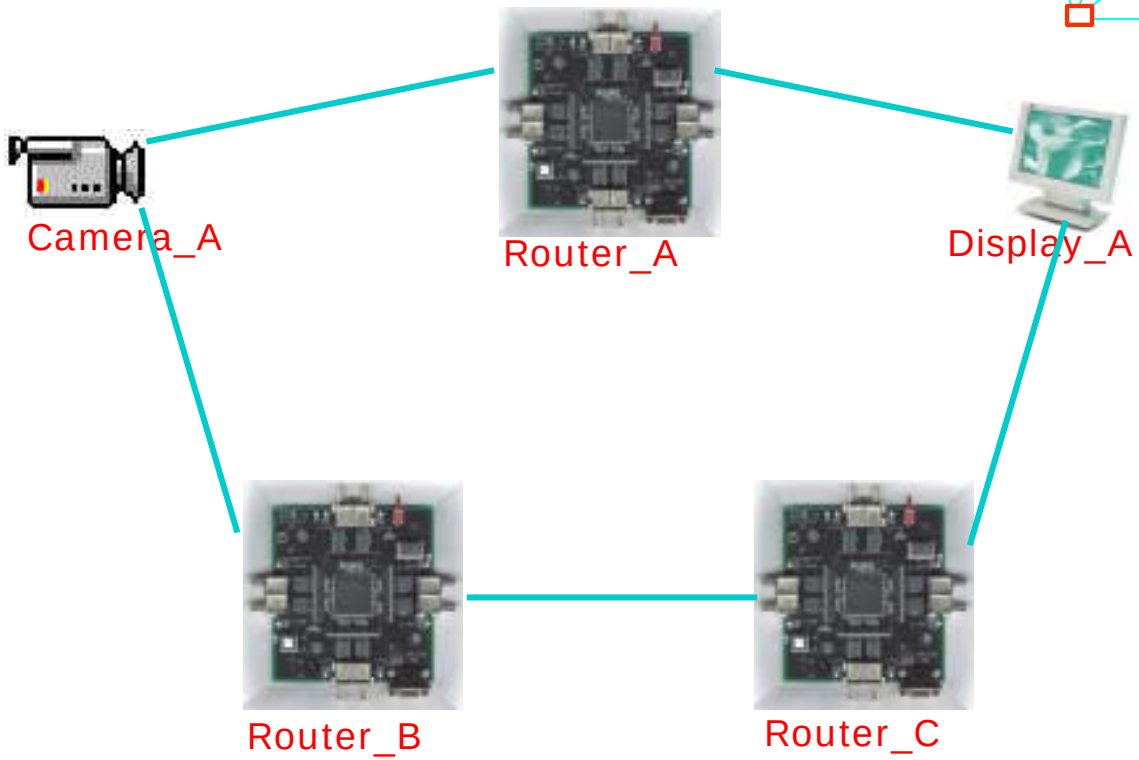

- **Dual-port nodes with small routers,**
- **Connected via routers in Ring**
- **Tolerant of failure of any link or router**

Examples with 4Links demonstration

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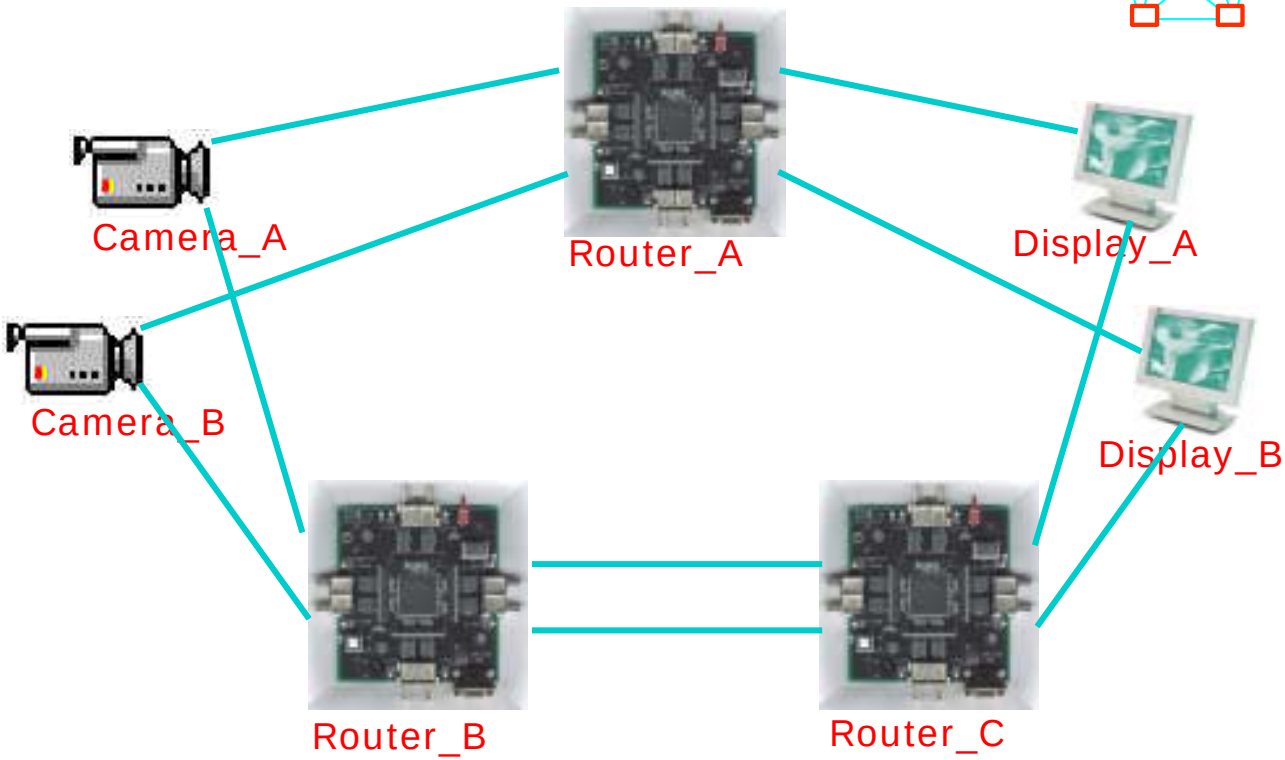

- More dual-port nodes with small routers,
- Connected via routers
- Tolerant of failure of any link or router

4Links Network Management

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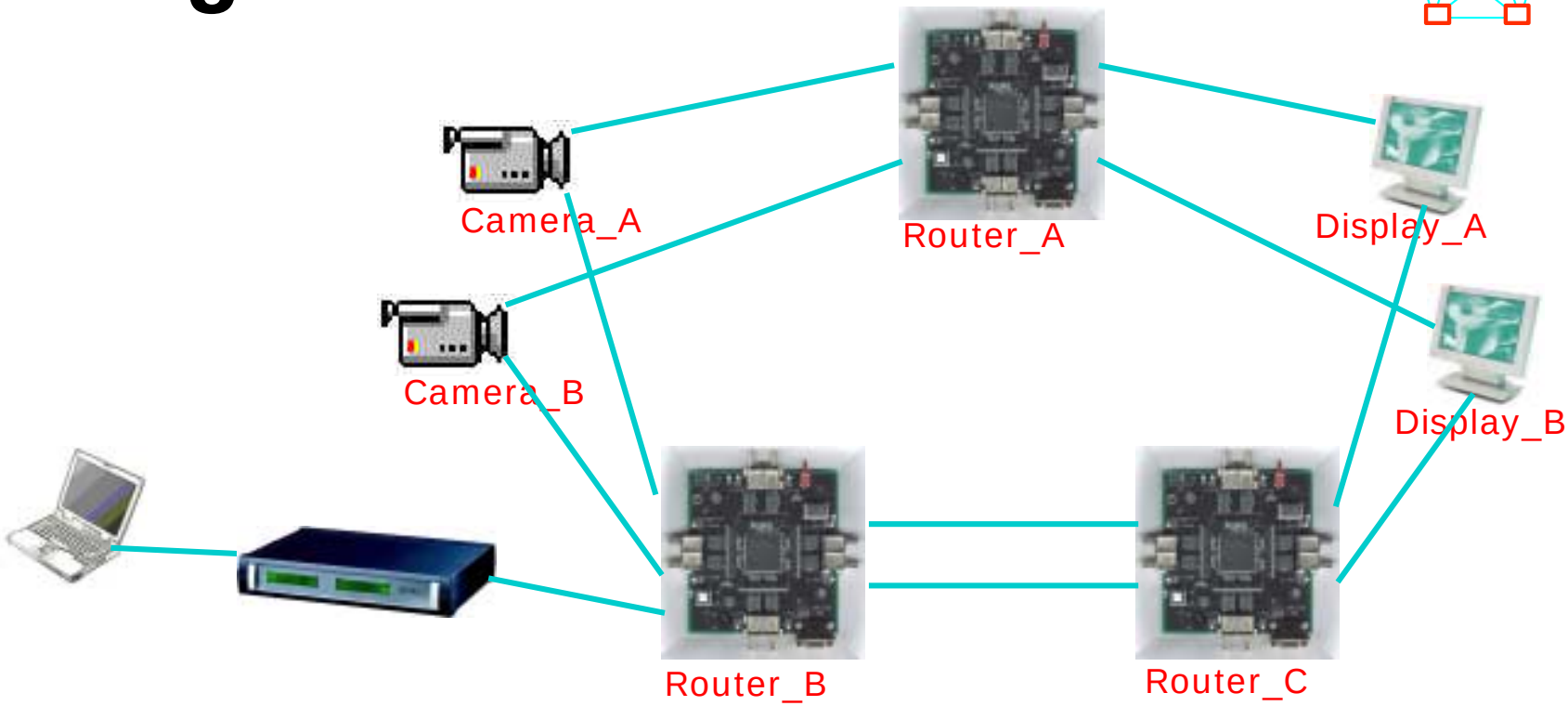

- **Network Management via EtherSpaceLink**
- **Intuitive user interface**
- **Simple enough to distribute to each node**

4Links FDIR

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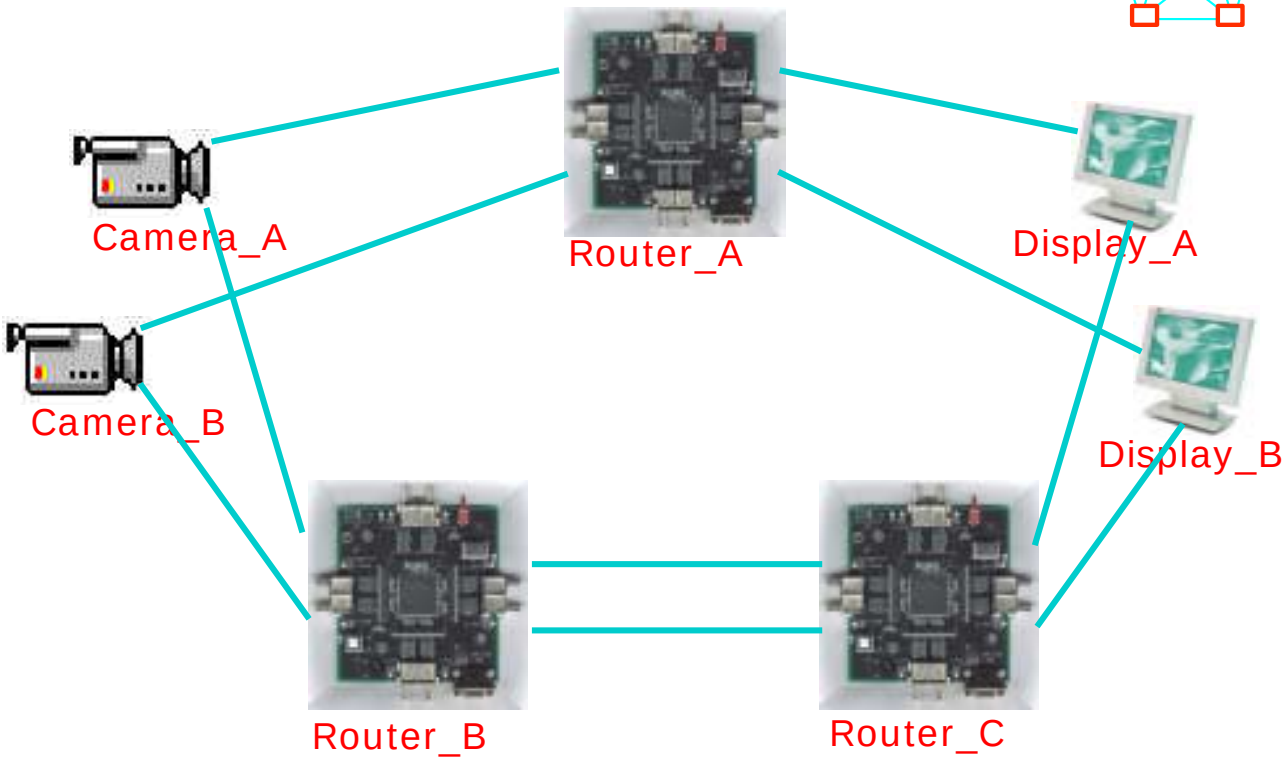

- **Autonomous**
- **Distributed between nodes**

Modularity and re-use

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- Possible with SpaceWire just as with Transputer

- Platform as well as Payload

Processor Performance, Reduced Dependency

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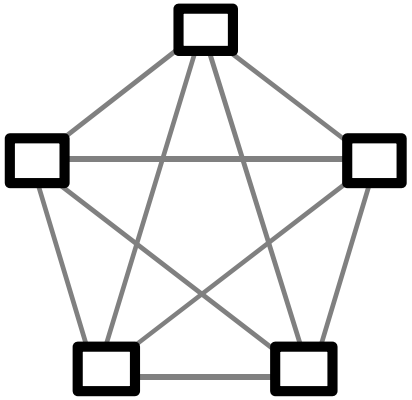
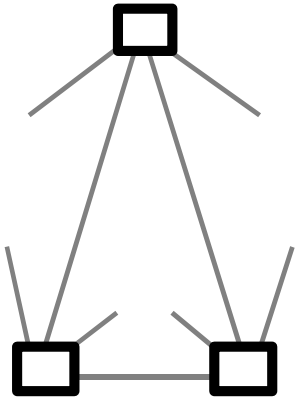
- **Commercial, State of art microprocessors**
- **Batch tested to find best batches for space**
- **Use redundant network of SpaceWire Links**





Processor Performance, Reduced Dependency

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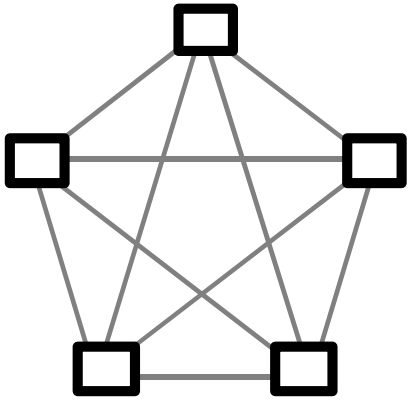

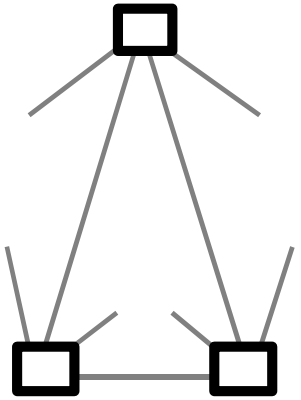

- **Rad-Hard by System Design**
- **But need to minimise I/O latency**

Conclusions

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- SpaceWire makes it easier to build systems
- Point-to-point without routers is like fast RS422
- Subsystem nodes with two SpaceWire ports reduce harness, reduce complexity
- Larger routers give more bandwidth
- Mix and match routers as best for system
- 4Links have been demonstrating that it works!
- More opportunity for modularity and re-use
- Improved Time Codes help real-time systems
- Could use commercial processors with SpaceWire for reduced dependency