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SPIDER: Flexible and Efficient Communication Support for Point-to-Point Distributed Systems

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June 24, 1994

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Outline

- Motivation
- Flexible routing and switching
- SPIDER architecture
- Protocol support
- Current status and conclusions

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Real-Time Applications

Applications

- Industrial process control
- Computer-integrated manufacturing
- Fly-by-light/drive-by-wire

Communication requirements

- Bounded network access delay
- Resource allocation and scheduling
- Fault tolerance

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Point-to-Point Distributed Systems

- Independent node and link failures
- Multiple disjoint routes between nodes
- High bandwidth
- Scalability

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Why Hardware Communication Support?

Low-level protocol processing burdens communication software:

- Multiple high-speed links
- Packet routing and switching
- Buffer management
- Data copying
- Error detection

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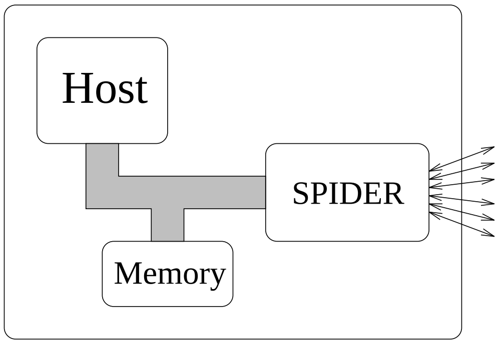
SPIDER (Scalable Point-to-point Interface DrivER) Node



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Why Flexible Communication Hardware?

- Irregular topologies
- Variable packet size
- Multiple communication protocols
- Diverse performance requirements
- Control over packet scheduling

→ flexibility close to the physical links

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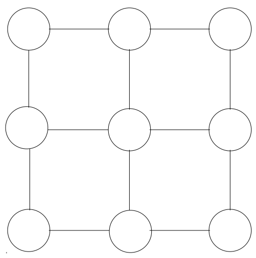
Routing and Switching

Routing: Which nodes/links a packet traverses.

Switching: How the packet flows through nodes/links in its route.



→ tailor to application and system requirements

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Flexible Routing

Flexible selection of output channels supports:

- Static routing
  → in-order delivery, predictable resource usage
- Adaptive routing
  → congestion-avoidance, fault tolerance
- Multicast
  → efficient group communication
- Irregular topologies
  → general networks, reconfiguration

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Flexible Switching

Flexible control over channel reservation facilitates:

- Circuit switching
  → guaranteed network access
- Packet switching
  → control over scheduling and bandwidth allocation
- Virtual cut-through switching
  → low latency, reduced intrusion from in-transit traffic
- Wormhole switching
  → low latency, complete insulation from in-transit traffic

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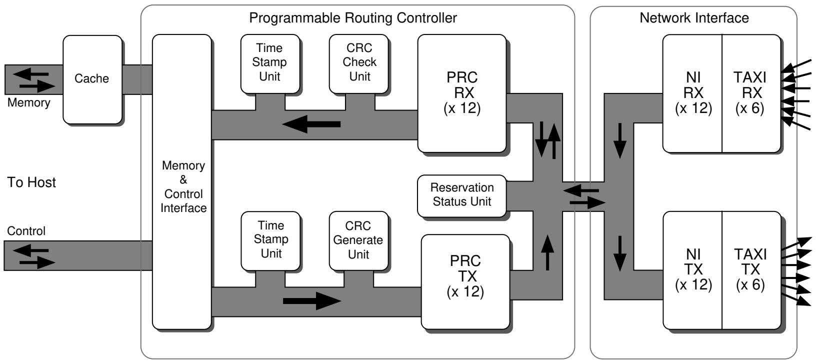
SPIDER Architecture



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Support for Efficient Protocol Processing

Host exercises *page*-level control over SPIDER:

- Page tag queues for each incoming/outgoing channel
- Event queue logging page-level activities

Flexibility:

- Scatter-gather DMA for each channel
- Variable packet size
- Partial cut-through
- Interrupt masking

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Support for Dependability

- Transparent CRC unit close to physical links
- Multicast primitive for group communication
- Multiple node-disjoint routes
- Fault-tolerant routing
- Irregular topologies

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Support for Real-Time Communication

- Timestamp unit close to physical links
- Fair, binary priority tree arbitration
- Fine-grain interleaving at memory and network interfaces
- Host scheduling for buffered packets
- Support for circuit switching
- Separate virtual networks

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Current Status and Future Work

- PRC chip designed and simulated using Epoch Verilog
- VME-based SPIDER board under development
- Cycle-level simulations of a mesh of SPIDERs
- Software protocols for point-to-point distributed systems

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Conclusions

SPIDER insulates the software from low-level protocol processing without precluding control over network policies.

- Offloads processing from software protocols
- Exploits concurrency at the physical links
- Interfaces to a variety of topologies
- Implements multiple routing and switching schemes

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