Optical Fiber Computer Interconnect: The Simultaneous Multiprocessor Exchange (SOME)-Bus

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Disciplines

- Optical Engineering
- Electrical Engineering
- Computer Engineering

Outline

- Computer Networks
- Electronic and Optical Technologies
- SOME-Bus Architecture
- Optics and Electronics Implementations
- Programming Support
- Future Work
- Conclusions

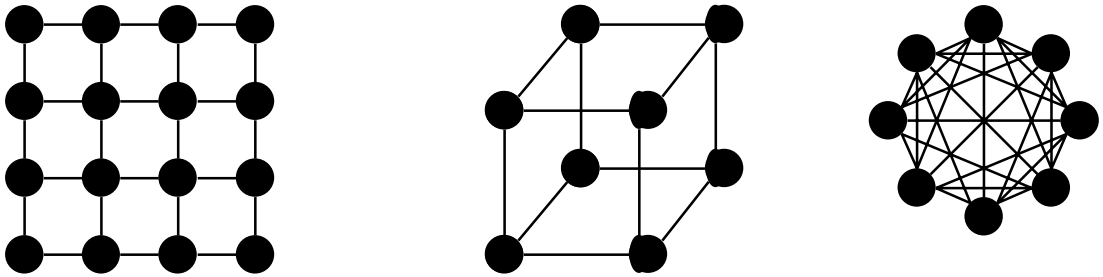
Computer Networks

- Carries information between processors
- Influences computer system performance
- Many Variations
  - Shared Bus
  - Point-to-Point

Shared Bus

- Single set of wire(s) used for data exchange, e.g. Ethernet segment
- Advantages
  - Low wiring costs
  - Direct connection between processors
- Disadvantages
  - Limited communication bandwidth
  - Arbitration overhead

Point to Point



- Dedicated sets of wires used between pairs of processors
- Advantages
  - Greater aggregate bandwidth
  - Limited number of taps on channel
- Disadvantages
  - More wiring
  - Processors not directly connected

Electronics Technology

- Advantages
  - Dense digital VLSI circuitry
  - Inexpensive fabrication

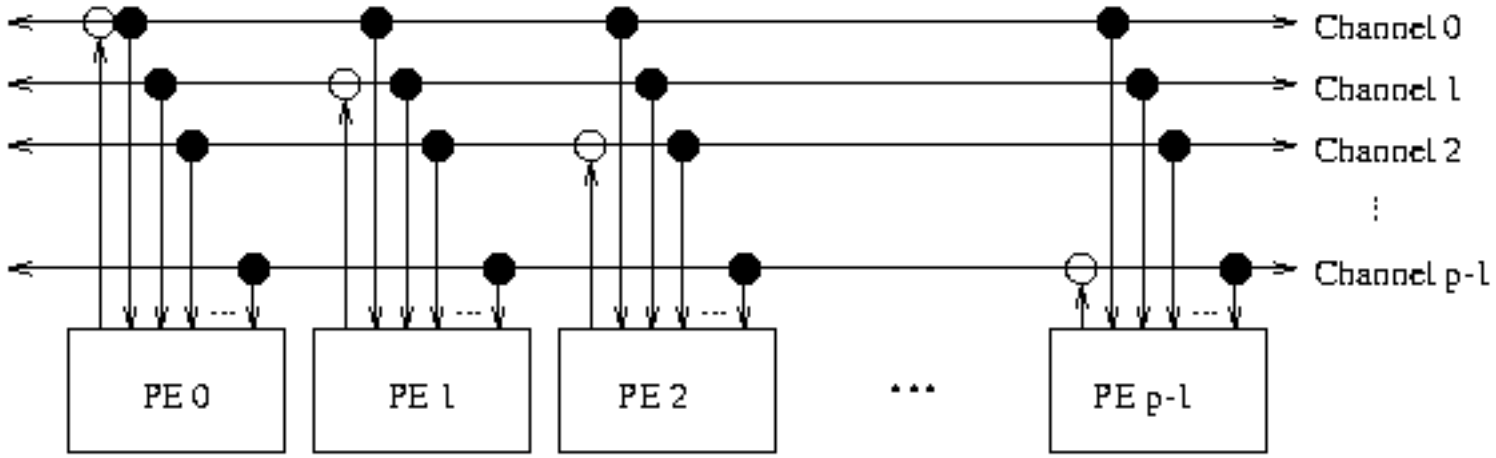
- Disadvantages
  - Low fan-out of signals
  - Low bandwidth per channel
  - Point-to-point communication channels

Optics Technology

- Advantages
  - High fan-out of signals
  - High bandwidth per channel
  - Multi-cast communication channels

- Disadvantages
  - Single point insertion
  - Weak computing facilities

SOME-Bus Architecture



- Exploits strengths of electronics and optics technologies
- One dedicated unidirectional channel per processor
- Each processor observes all channels
- Performance not limited by communication medium (fiber)

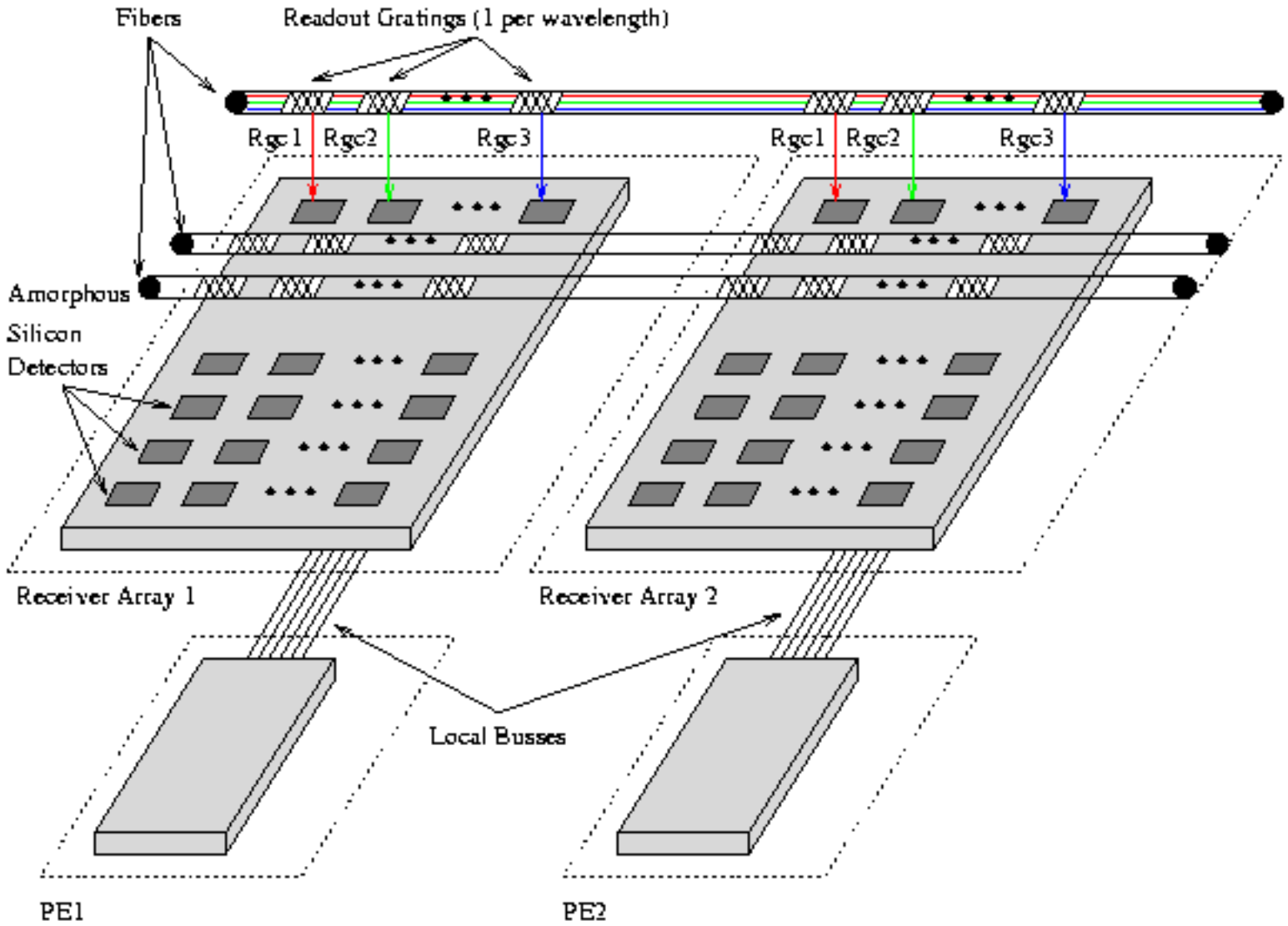
Network Characteristics

N processors	Diameter	Channels	Trans-mitters	Re-ceivers
SOME Bus	1	N	N	$(N)^2$
Shared Bus	1	1	N	N
Mesh	$(N)^{0.5}$	4N	4N	4N
Hypercube	$Log_2(N)$	$N\ Log_2(N)$	$N\ Log_2(N)$	$N\ Log_2(N)$
Fully connected	1	N(N-1)	N(N-1)	N(N-1)

Optics Implementation

- Ribbon of multiple optical fibers
- Input coupler
  - One per fiber
  - Multiple wavelengths of light
  - Multiple processor channels on single fiber
- Output coupler
  - Multiple output couplers per fiber
  - Bragg grating in fiber
  - Wavelength specific
  - Very small output per grating (~1%)
  - Aligned with optical detectors

SOME-Bus Implementation



Electronics Interface

- Integrated Circuit (IC)
  - Array of receivers
  - Interface to Processor bus
  - 128 1024 byte buffers and associated logic fit in a die size of 1.6 cm x .8 cm
- Receiver Functions
  - Convert optical detector's analog signal into digital signal
  - Filters out uninteresting bus traffic
  - Buffer data until processor bus available

Programming Support

- Communication models
  - Shared memory
  - Message passing
- Simplified model for programming
  - Direct connections between processors
  - No interference on channel from other processors
- High-speed broadcast
- Fast barrier synchronization mechanism

Factors Affecting Performance

- Bandwidth is an important concern, but not the only one
- Latency is critical in many computer operations such as
  - Cache coherency messages
  - Shared memory data exchanges
  - Handshaking and synchronization signals
- Network flow control/resource allocation

Future Work

- Form gratings in fibers and characterize footprint and selectivity
- Examine issues of inter-mixed analog and digital circuitry
- Build silicon v-groove devices to hold fibers for alignment with photodetectors
- Characterize performance for realistic program loads using simulations.
- Investigate whether diffractive optic elements are required, build if necessary
- Build and characterize 32 channel prototype

Conclusions

- Bandwidth scales with the number of processors
- Network diameter = 1
- Supports shared memory, message passing and synchronization
- As technology matures, the system bandwidth will increase

Receiver Front End Logic