



Network Processors

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Embedded Systems

- Software-oriented
 - General-purpose CPU
 - Embedded processor or system-on-a-chip
 - What are my computation requirements?
 - Do I need hardware assist units?
- Hardware-oriented
 - Fixed logic (ASICs)
 - Reconfigurable logic (FPGAs)
- Combination of hardware and software
- Are there other options?

Specialized Processors

- Think about a digital signal processor
 - Specialized core for DSP operations
 - Low precision arithmetic
 - Multiply-accumulate instructions
 - Program-controlled memories
 - ...
 - Likely to also have appropriate hardware assist units
 - More efficient than general purpose processors
 - ... for digital signal processing
- What about networking?

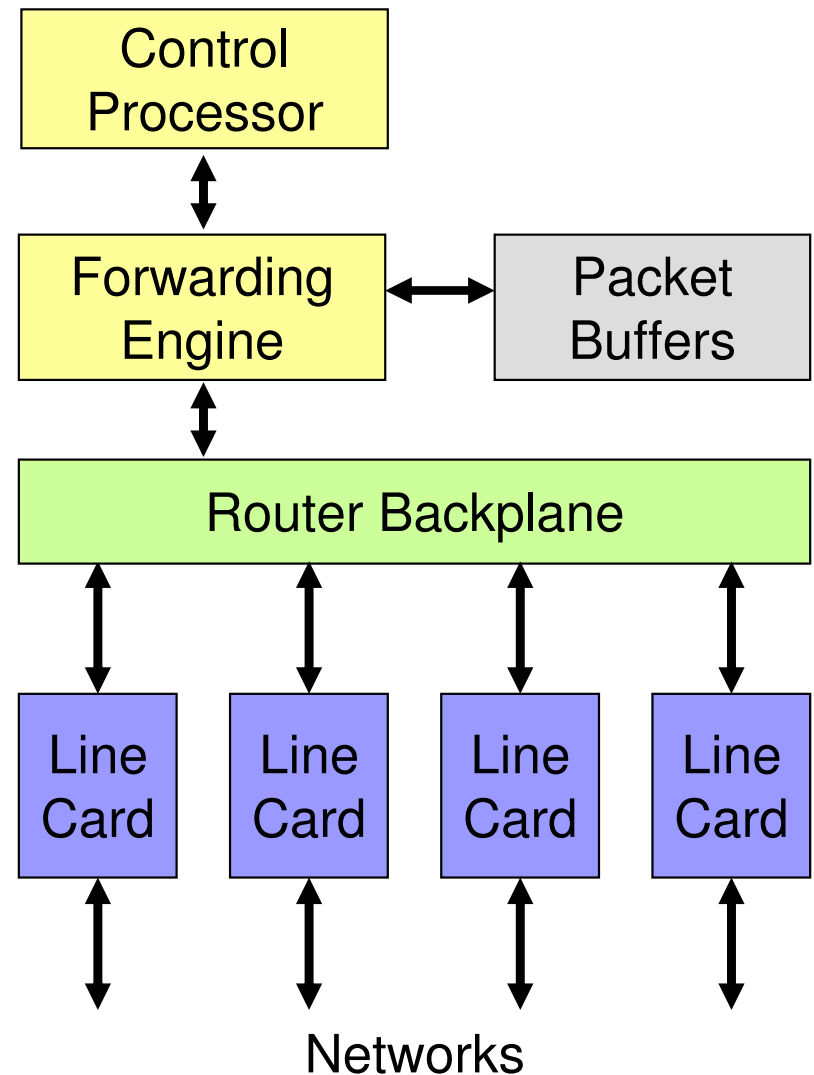


Network Processing

- What are the characteristics of network processing?
- How can we more efficiently exploit those characteristics in a specialized processor?

Basic Router Components

- Key Modules
 - Network Interface
 - Packet processing
 - Packet buffering
 - Packet switching
- Processing and buffering can be centralized or decentralized



Packet processing

- Analyze packet and extract header information necessary for router functions
- Might need to
 - Segment
 - Forward
 - Queue
 - Police
 - Reassemble
 - Discard
 - ...



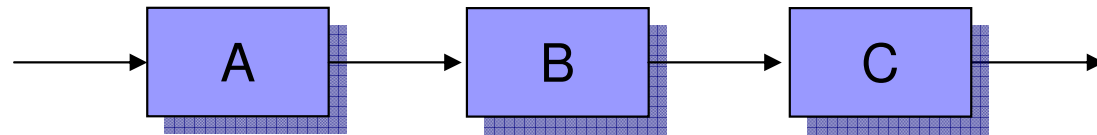
Parallelism

- How much parallelism is available?
- How can a programmable processor exploit it?

Network Processors

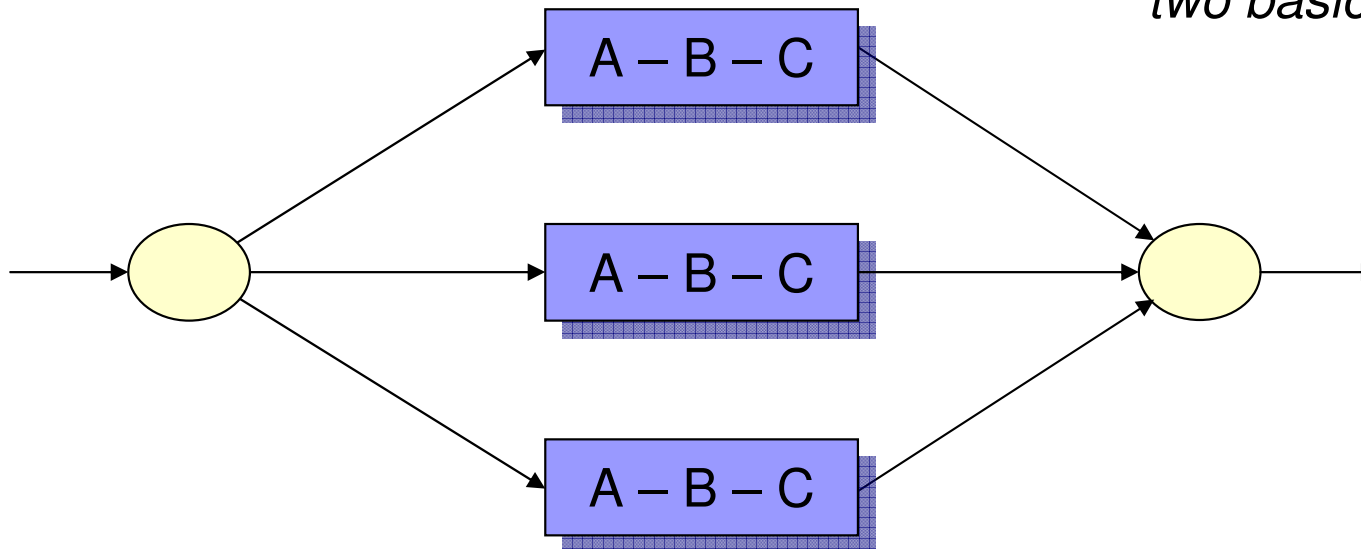
- Multicore
 - Multiple processors on a single chip
 - Well before general purpose processors
- Multithreaded
 - Multiple threads run on each processor
 - Before Intel's hyperthreading
- Usually don't bother with instruction-level parallelism
 - Why?
- Usually don't bother with caching
 - Why?

Organization



Pipelined

Imagine all potential combinations of these two basic techniques!



Parallel

Network Processors

- Try to turn system design from a *silicon problem* to a *programming problem*
 - Can we develop software faster than we can develop custom hardware? (*probably...*)
 - Is the development cheaper? (*probably...*)
- Provide greater flexibility than ASICs or FPGAs
- Challenge: Processor design must be fixed before exact problem to be solved is known
 - Processors have to provide generalized functions to meet a wide range of customer demands

Special Network Processor Features

- Pattern matching
 - Find bits in a stream
- Lookup acceleration
 - Hash index, hash search, etc...
- Bitfield manipulations
 - Edit packet headers
- Queue management
 - Add / remove packets from queues
- CRC / checksum accelerators
- Integrated interfaces to network I/O
- Crypto support (encryption / key management)
- “Magic memory” (i.e. auto-incrementing counters)
- *Lots more...*
- Plus general-purpose control processor(s)



Benefits

■ Programmability

- Add new services/features
- Modify/fix existing services/features
- Same network processor could be used in multiple scenarios

■ Performance

- Much better than using a conventional PC

Drawbacks

■ Programmability

- Difficult to program

- Memory

 - Multiple program controlled memories

 - Packet buffer management

- Processors

 - Often programmed in assembly language

 - Parallelism extracted manually

 - Packet processing must be scheduled

 - Tight timing constraints

Packet Buffering

- All packets must enter and leave packet buffers
- Bandwidth can be a big challenge!
 - 10Gbps link: packets arrive/leave every 64ns
 - 20Gbps of memory bandwidth per link
 - 1 byte per direction per ns per link!
- Scheduling
 - Packets must be kept in order (or intentionally reordered)



NPs vs. ASICs vs. FPGAs

- Power
- Performance
- Flexibility
- Cost

Network Processors

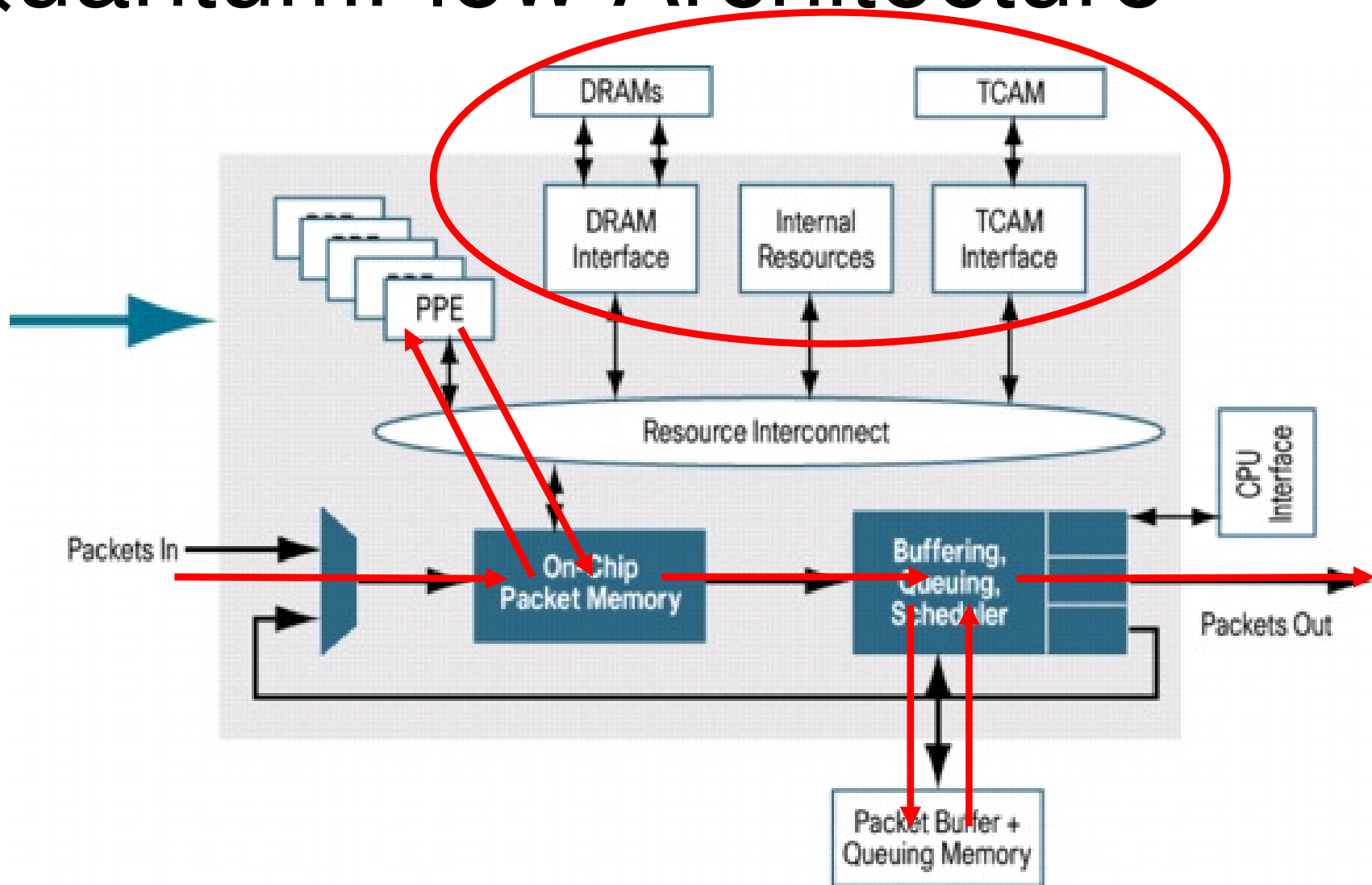
- Network processors were very popular ~2000
 - Many, many startup companies
 - Many big (Intel, IBM, etc.) companies
- You don't hear much about network processors these days, though
 - http://en.wikipedia.org/wiki/List_of_defunct_Network_Processor_companies
 - Lists 35 companies – probably not complete



Cisco QuantumFlow

- QuantumFlow Processor Engine
 - Provides packet processing
 - 40 Packet Processor Engines
 - Multithreaded (4 threads per PPE)
 - Fully programmable in C
- QuantumFlow Processor Traffic Manager
 - Provides buffering, queueing, and scheduling
 - Flexible, real-time scheduling
 - 100,000+ queues

QuantumFlow Architecture



- From http://www.cisco.com/en/US/prod/collateral/routers/ps9343/solution_overview_c22-448936.html

Schedule

■ This week

- Friday: No class (Jeff/Mike/Thomas gone)
 - *Great time to work on projects!*

■ Next week

- Monday: IPv6
- Wednesday: Project Meetings
- Friday: No class (Midterm recess)
 - *Great time to work on projects!*