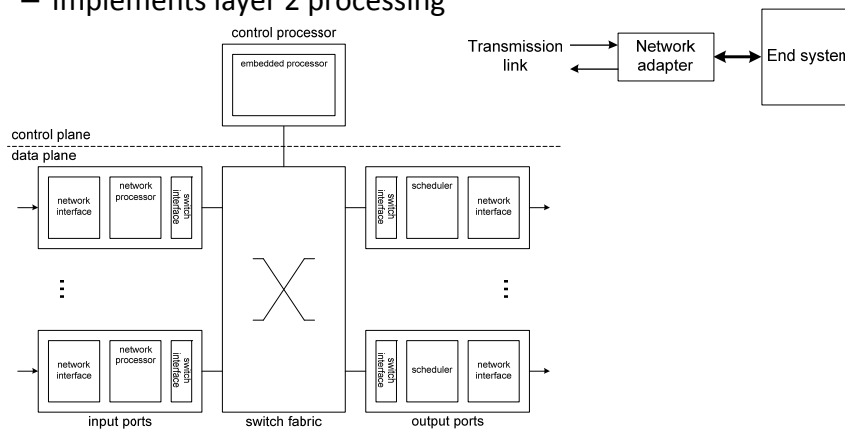


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Network Adapters

Network adapters

- Use in network system or end-systems
 - Implements layer 2 processing

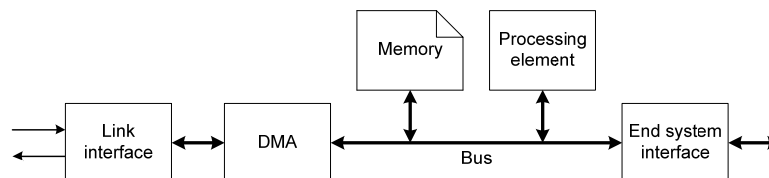


Design challenges

- Throughput preservation
 - Needs to sustain link data rate
- Asynchronous operation
 - Asynchronous packet arrival
 - Variable packet size
- Interface to processor
 - Avoid negative impact on processing performance

Basic network adapter

- How does packet reception and processing work?

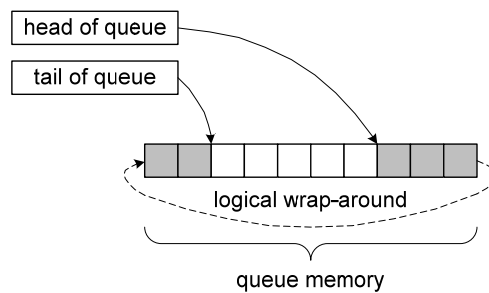


How to store a packet in memory?

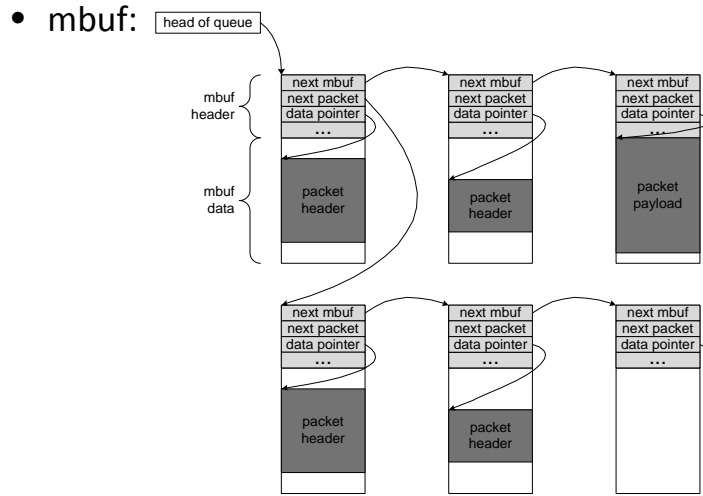
- What data structures are suitable for packet storage?

Packet buffer

- Ring buffer:



Packet buffer

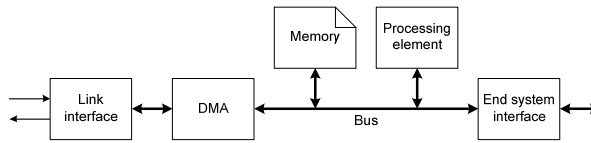


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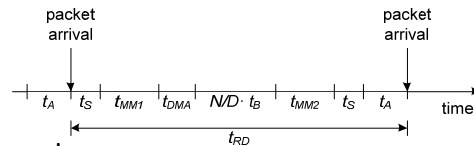
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Performance estimation



- Consider each step:
 - Task switch: t_s
 - Get address of free memory: t_{MM1}
 - Set up DMA controller: t_{DMA}
 - Transfer packet over bus: $N/D \cdot t_B$
 - Append packet to queue: t_{MM2}
 - Time to next packet: t_A



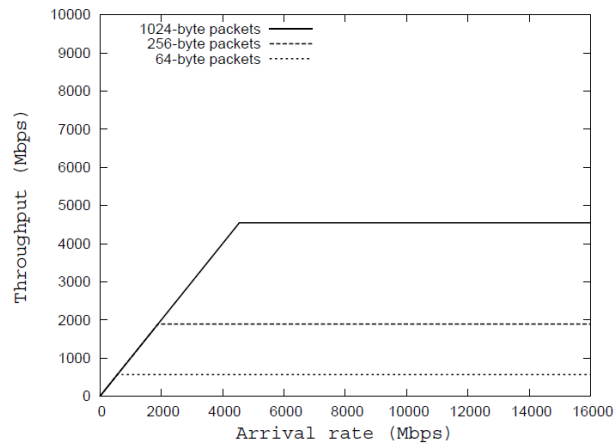
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Throughput performance

- Simulation of baseline adapter:



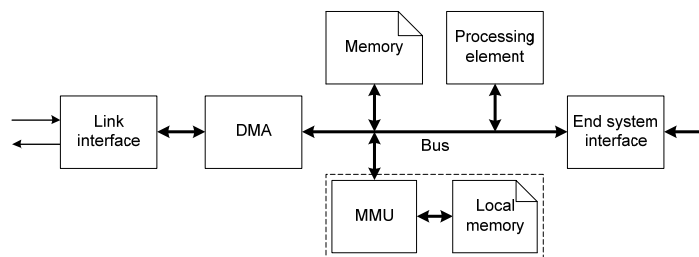
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Memory management

- MMU uses specialized hardware to manage memory
 - Enqueue/dequeue operations
 - Free lists
 - Local memory maintain information about main memory
- MMU implements operations faster than software



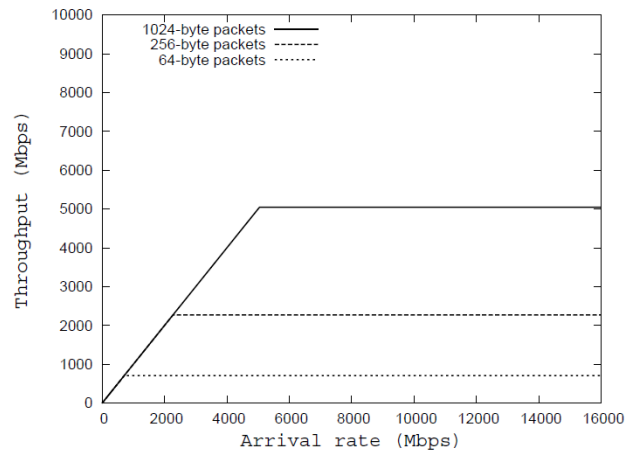
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Throughput performance

- Simulation of adapter with MMU:



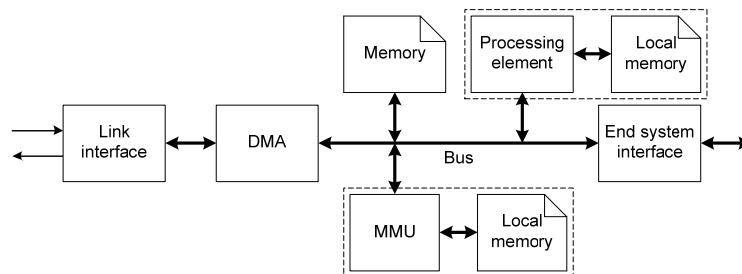
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Local memory for processor

- Processor is idle during data transfers
 - Cannot access memory via bus
- Local memory for processor for parallel operation
 - Pipelining of data transfers and processing



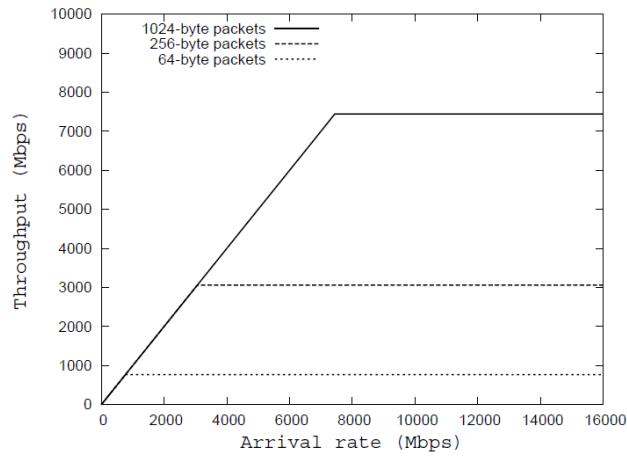
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Throughput performance

- Simulation of adapter with MMU and local memory:



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Further improvements

- Other techniques to improve throughput
 - Intelligent DMA (no processor setup required)
 - Multiprocessor configuration (parallel operation possible)
 - Multiple MMUs
- Details in textbook

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Network adapters and OS

- On end-system, protocol stack is implemented in OS
 - Network adapter implements Layer 2 processing
 - OS implements Layer 3-5/7 processing
- How is asynchronous packet arrival handled?