Introduction to Queue Management Algorithms

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Overview

- Router architecture

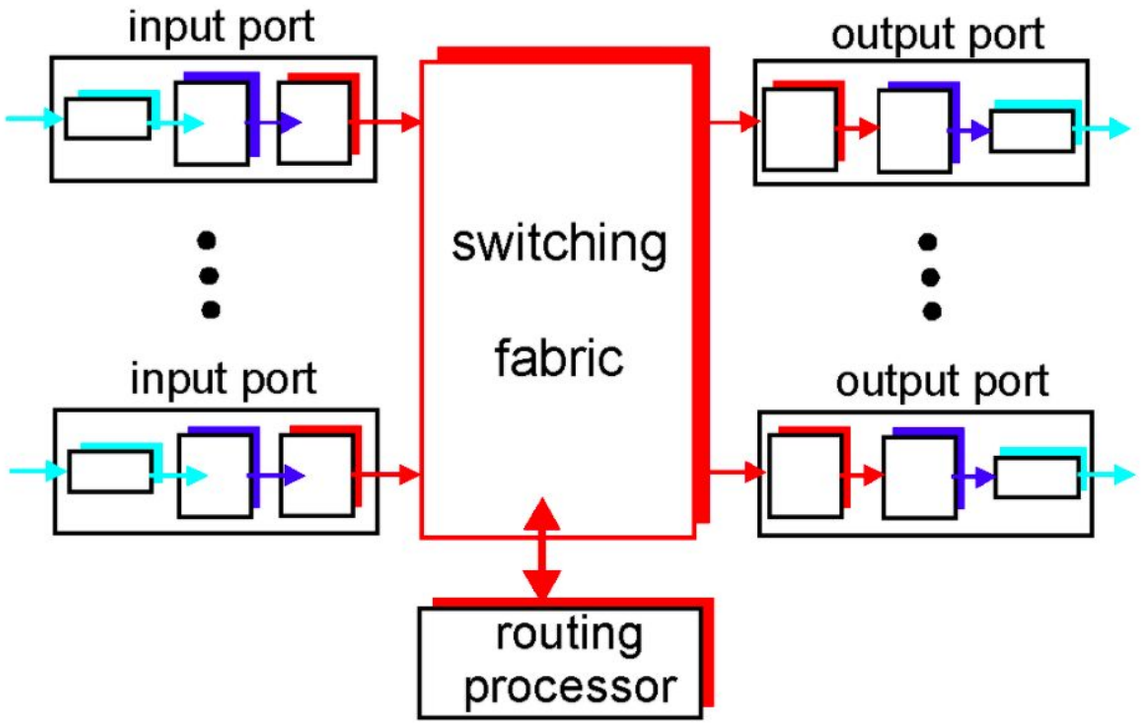

Fig. 1: Packet processing in router

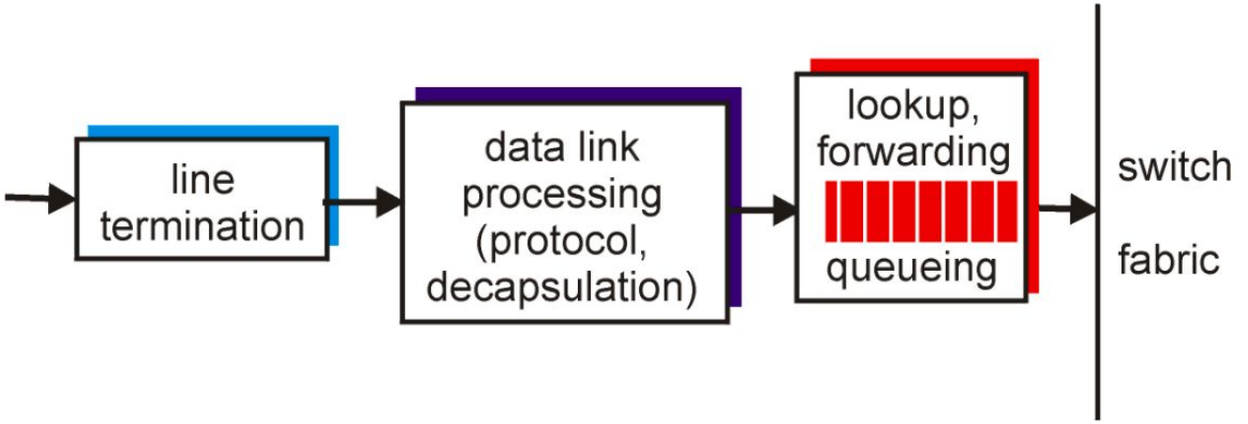

Fig. 2: Processing at the Input port

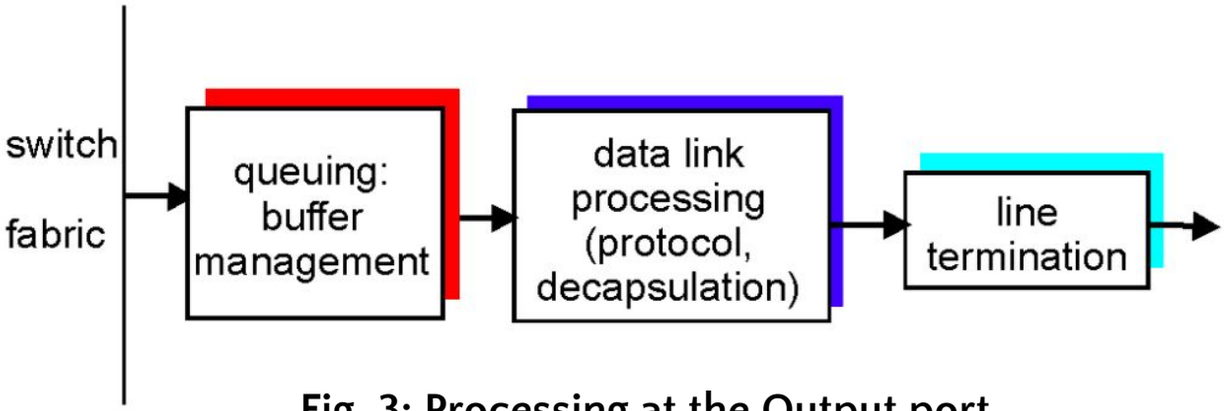

Fig. 3: Processing at the Output port

Image Credits: https://www2.ic.uff.br/~michael/kr1999/4-network/4_06-inside.htm

Overview (contd ...)

- When does congestion occur?

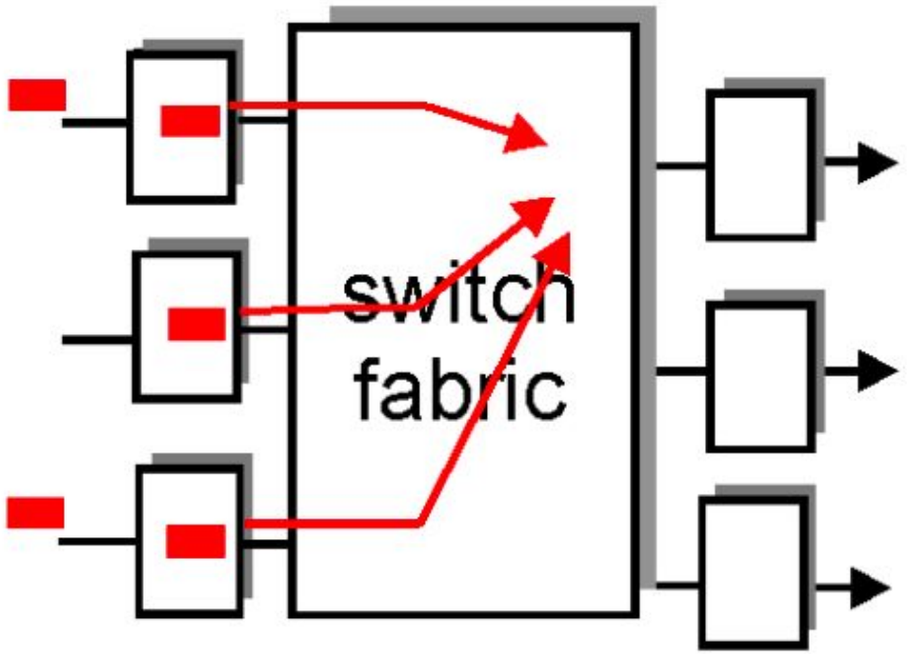

Image Credits: https://www2.ic.uff.br/~michael/kr1999/4-network/4_06-inside.htm

Overview

- Queue management algorithms
  - a.k.a queue disciplines (qdiscs)
  - Can be classified into
    - Passive Queue Management (e.g., FIFO)
    - Active Queue Management (e.g., Random Early Detection)
  - Passive Queue Management algorithms
    - reactive in nature i.e., they operate ‘after’ the queue is full
    - easy to deploy
    - difficult to provide queue control with PQMs
  - Active Queue Management algorithms
    - proactive in nature i.e., they operate ‘before’ the queue is full
    - easy to moderate difficulty in deployment
    - provide good queue control

Passive Queue Management

- DropTail
  - drops the packets from the ‘tail’ of the queue
  - acts like a simple FIFO queue
- DropHead
  - drops the packets from the ‘head’ of the queue
  - a.k.a. ‘DropFront’ (this name is used in ns-2)
  - Question: What is the advantage of using DropHead?
- Random Drop
  - drops the packets from a random ‘position’ in the queue
  - Question: What is the advantage of using Random Drop?

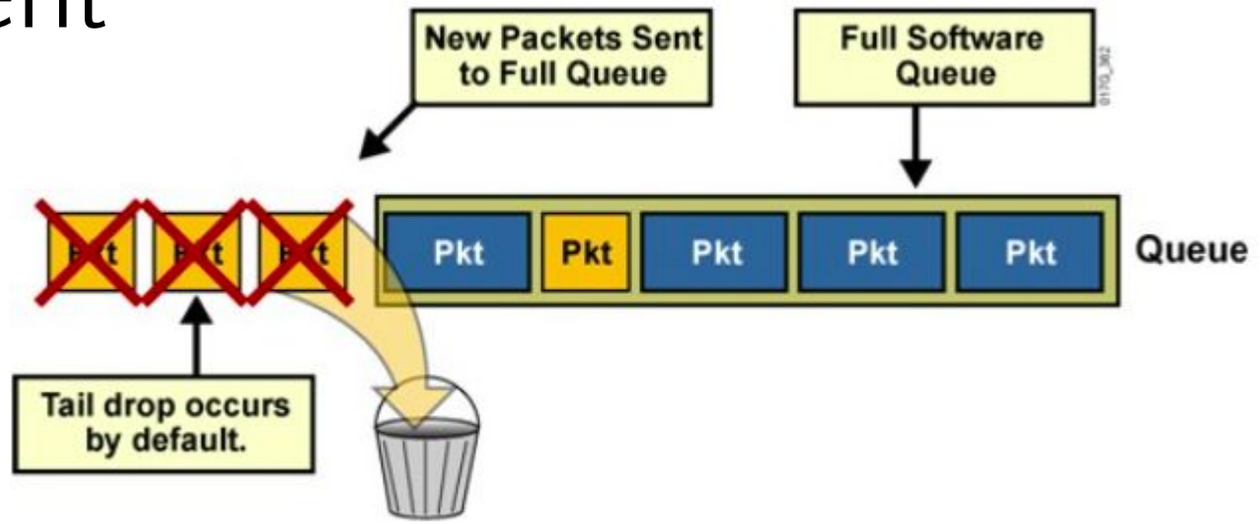

Image Credits: https://slideplayer.com/slide/9996714/

Limitations of PQM algorithms

- Global Synchronization
  - Multiple TCP flows start at different times
  - Congestion window of all TCP connections increase
  - DropTail causes many packets of all the flows to be dropped at the same time
  - TCP flows reduce their congestion window at the same time (synchronized)
  - Subsequently, all TCP flows increase their congestion window at the same time (synchronized)
  - Frequent periods of link ‘overutilization’ and ‘underutilization’. This adds jitter (variation in delay).

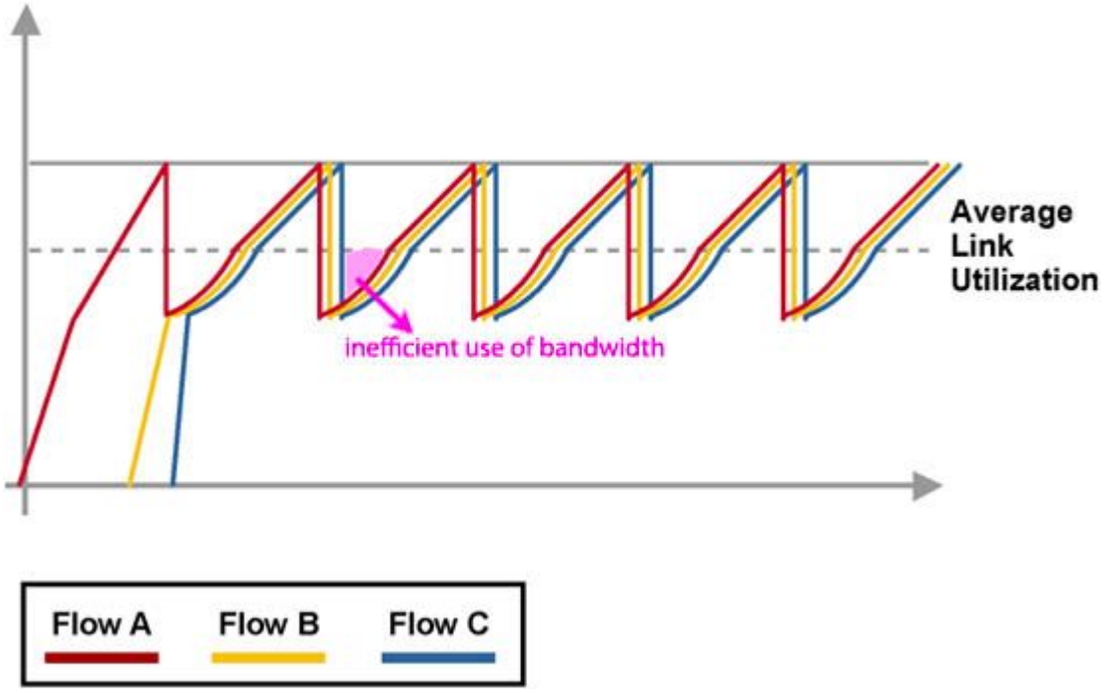

Image Credits: https://www.digitaltut.com/tcp-udp-questions

Limitations of PQM algorithms (contd …)

- Lock Out
  - DropTail allows a few flows to monopolize the queue space
    - These flows are typically long lasting flows (a.k.a ‘elephant’ flows)
  - Short flows do not get sufficient space in the queue due to large occupancy of elephant flows
    - Packets of short flows get dropped. This phenomenon is called ‘Lock Out’
- Bufferbloat
  - Memory prices have fallen sharply.
    - Hence, buffering capacity has increased.
  - Excessive buffering leads to ‘high queuing delays’.
    - It was reported that queuing delays sometimes rise so much that TCP RTO expires!
  - Time sensitive applications are the worst affected ones due to bufferbloat.

Interesting things to check in Linux kernel!

- Queue disciplines are implemented in net/sched directory
  - Link: https://github.com/torvalds/linux/tree/master/net/sched
- Example: FIFO queue discipline in implemented in the following file:
  - Link: https://github.com/torvalds/linux/blob/master/net/sched/sch_fifo.c
- Explore in Linux's sch_fifo.c file:
  - bfifo queue disc (Man page: https://www.man7.org/linux/man-pages/man8/tc-bfifo.8.html)
  - pfifo queue disc (Man page: https://linux.die.net/man/8/tc-pfifo)
- What is traffic control sub-system in Linux?

Recommended Reading

What's inside a router?
Link: https://www2.ic.uff.br/~michael/kr1999/4-network/4_06-inside.htm

Bufferbloat website
Link: https://www.bufferbloat.net/projects/