Modeling Packet Scheduling Algorithms in IP Routers

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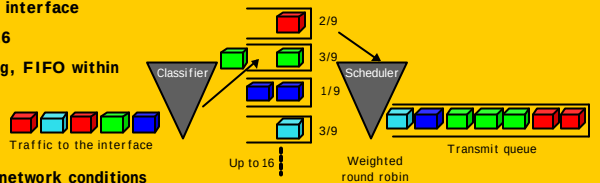
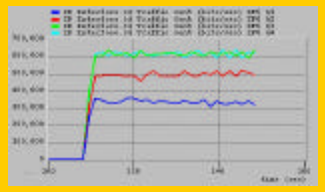
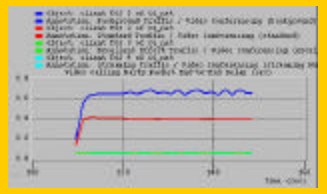
Custom Queuing

- Packet classification: based on protocol or interface
- Number of queues: equal to or less than 16
- Scheduling: weighted round robin scheduling, FIFO within priority queues
- Usage: not used for voice
- Advantage: guarantees BW per queue
- Disadvantage: does not adapt to changing network conditions

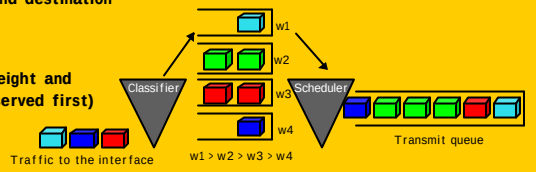


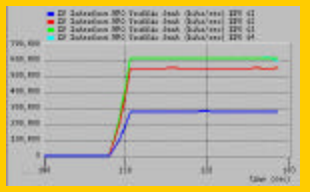

Outgoing traffic from each queue

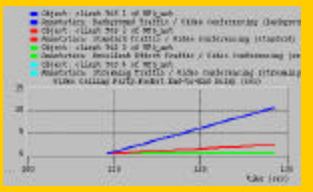

Average end to end delay of packets in each queue

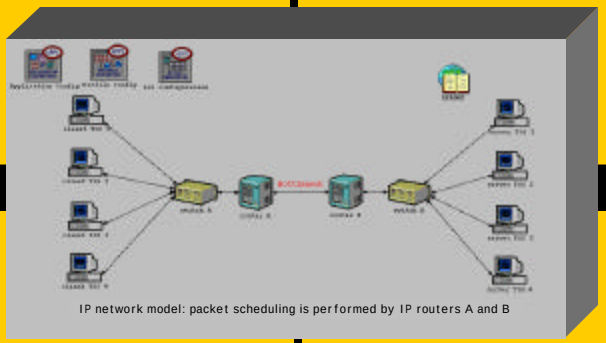
Weighted Fair Queuing

- Packet classification: based on protocol or source and destination addresses
- Number of queues: equal to the number of flows
- Scheduling: "fair" algorithm based on both queue weight and the arrival time of each packet (lower weights are served first)
- Usage:
  - works well for data traffic
  - not recommended for voice, but can be used when no alternative is available
- Advantage: dynamically adapts to changing network conditions



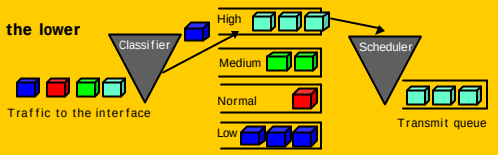

Outgoing traffic from each queue

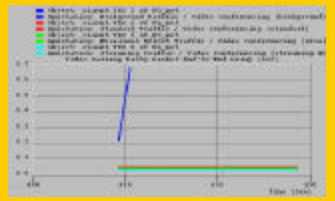

Average end to end delay of packets in each queue


IP network model: packet scheduling is performed by IP routers A and B

Priority Queuing

- Packet classification: based on protocol or interface
- Number of queues (4): high, medium, normal, and low
- Scheduling: serves packets from each queue (high to low priority) in FIFO order until each queue becomes empty
- Disadvantages:
  - delay is transferred from the high priority queue to the lower priority queues
  - lower priority queues may starve
- Usage:
  - works well for a small number of traffic types
  - not used for voice




Average end to end delay of packets in each queue

References:

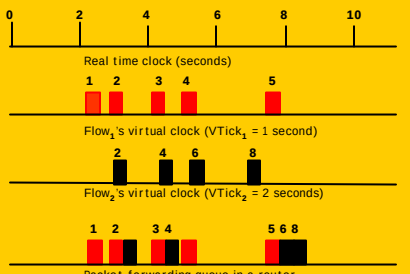
[1] L. Zhang, "VirtualClock: A new traffic control algorithm for packet switching networks," ACM SIGCOM, Sep. 1990.

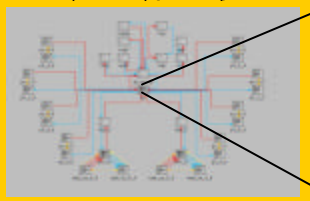
[2] Cisco Systems Inc. documentation on QoS:
http://www.cisco.com/wrap/public/732/tech/quality/shtml

[3] OPNET Technologies Inc., Washington DC, OPNET documentation V.7.0.L.

VirtualClock

- Each flow has its own clock
- Assigns a separate queue to each flow according to:
  - IP address of the source
  - IP address of the destination
- Upon receiving a packet from flow$_i$,
  - VClock$_i$ = max (VClock$_i$, realtime)
  - clock ticks with (1/AR$_i$), VClock$_i$ <= VClock$_i$ + VTick$_i$ (= 1/AR$_i$)
- Stamps packets with VClock$_i$ values
- Services packets in increasing stamp order




Network hierarchy in the IP router node model


State transition diagram for "VirtualClock" process model