Flow control. Quality of services.

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Content

- QoS
- application requirements
- parameters of QoS
- technical solutions
    - ▶ SLA, SLS
    - ▶ queuing algorithms
    - ▶ RED, WRED
    - ▶ token bucket
    - ▶ leaky bucket

How to define QoS

- definition level:
    - ▶ network – throughput, delay, etc.
    - ▶ application – frames per second, transmission time, personal evaluation for voice services, availability, etc.
- type of definition:
    - ▶ quantitative
    - ▶ qualitative (relative)
- quality of service is the result of a joint activity of applications, middleware, OS and network.

QoS parameters I

- exact definitions:
  - ▶ IETF activities
    - IP Performance Metrics (IPPM) Working Group: defines metrics for performance measurements (delay, round-trip time, loss, etc.)
    - IP Flow Information eXport (IPFIX): defines protocol for export of flow data
  - ▶ ITU-T recommendations: I.350, I.381, Y.1541, Y.1545, Y.1561, etc.
    - QoS in specific networks (ISDN, ATM, MPLS, IP, Ethernet, etc.)
- parameters and metrics of network quality of service (QoS) could be used in agreements among network providers, and between end users and their network providers
- there is no uniform universal specification
  - ▶ several standardization organizations
  - ▶ individual projects
  - ▶ continuous attempts to better specify traffic classes

QoS parameters II

- quantitative parameters
    - ▶ delay
    - ▶ jitter
    - ▶ packet loss rate, bit error rate
    - ▶ throughput
    - ▶ availability
- qualitative parameters
    - ▶ classes

Quantitative parameters

description of the physical properties of the system

- immediately measured value
- relation to some time interval
- absolute limits ("never exceeds ...")
- quantile ("does not exceed 99% of the time ...")
- mean value and variance (σ) – for normal distribution

Delay

- RTT – Round-trip Time
  - ▶ both directions
  - ▶ easy to measure
- OWD – One-way Delay
  - ▶ may be different in both directions
  - ▶ difficult to measure – requires time synchronization

Delay: components

- transmission delay – time from first to last bit on medium:
  $D_T = N/S$, where N is the number of bits, S – transmission rate
- propagation delay – physical speed:
  - ▶ speed of light for vacuum or air
  - ▶ $\sim 2 \times 10^8$ m/s for electrical cable
  - ▶ $\sim 2 \times 10^8$ m/s for optical cable
- processing delay – header analysis, searching in routing tables, etc.
- queuing delay
  - ▶ output queue of the network interface
  - ▶ input queue of device processor (e.g. router)

Jitter

- one-way delay variation
- could be expressed as
    - ▶ absolute value: $D_{max} - D_{min}$
    - ▶ relative value: %
- important for real-time network communication
- compensated by the input buffer in the application
- critical for NTP

Data loss

- measured by number of lost transfer units
  - ▶ packets – packet loss rate (PLR)
  - ▶ bits – bit error rate (BER)
- depends on the medium
  - ▶ high for a wireless network (e.g. Wi-Fi)
  - ▶ very low for optical networks
- congestion of the line
  - ▶ dropping of packets $\Rightarrow$ data loss

Throughput

- network capacity (bandwidth) – theoretical data transfer rate
  - ▶ limited by a link with the smallest capacity
- throughput – actual data transfer rate
  - ▶ influence of repaired losses
- goodput – the application layer throughput
- available bandwidth
  - ▶ free transmission capacity
  - ▶ is rapidly changing
  - ▶ difficult to evaluate

Availability

- probability that the network (service) will be available
    - ▶ expressed relatively (e.g. 0.99 of the year)
- includes
    - ▶ technical faults
    - ▶ administrative restrictions (planned maintenance, updates, etc.)

Qualitative parameters

Classes

- best-effort
    - ▶ network does not provide any guarantees
    - ▶ user obtains unspecified variable bit rate and delivery time, depending on the current traffic load
    - ▶ standard in the Internet
- other classes – depending on the technology, different specifications, less implementations
    - ▶ sensitive traffic – guaranteed bandwidth, low packet loss rate
    - ▶ LBE (Less Than Best Effort)
    - ▶ undesired –

SLA/SLS

- SLA – Service Level Agreement
  - ▶ agreement on technical and non-technical service parameters between customer and provider
- SLS – Service Level Specification, specification of SLA technical parameters
  - ▶ Scope (ingress, egress, ...)
  - ▶ Flow description (IP addresses, ports, etc.)
  - ▶ Traffic envelope (peak rate p, token bucket r,b)
  - ▶ Excess treatment (drop, shape, remark)
  - ▶ Performance (loss, throughput, delay, jitter, ...)
  - ▶ Time
  - ▶ Reliability

Queuing Algorithms

- based on arrival: FIFO (First In First Out)
- based on priority: PQ (Priority Queuing)
- sharing of the capacity:
  - ▶ WFQ (Weighted Fair Queuing)
  - ▶ WRR (Weighted Round Robin)
  - ▶ MDRR / DRR (Modified / Deficit Round Robin)
- prevention of congestion
  - ▶ WRED / RED ((Weighted) Random Early Detection)
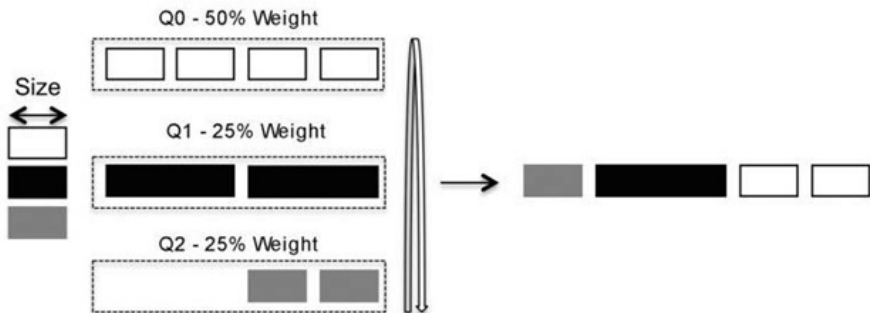
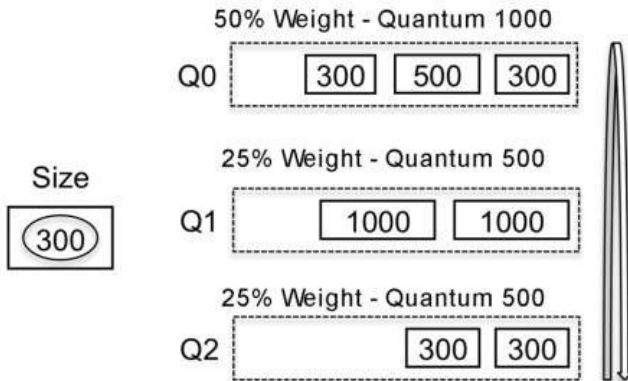# Priority Queuing
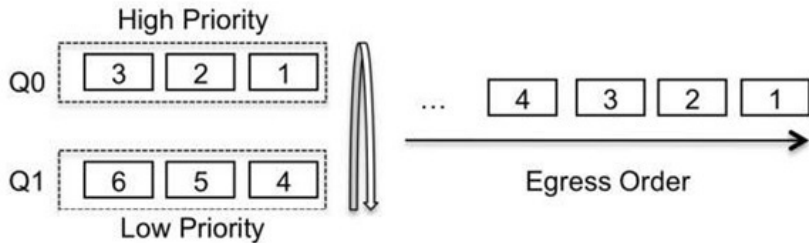
Weighted fair queuing
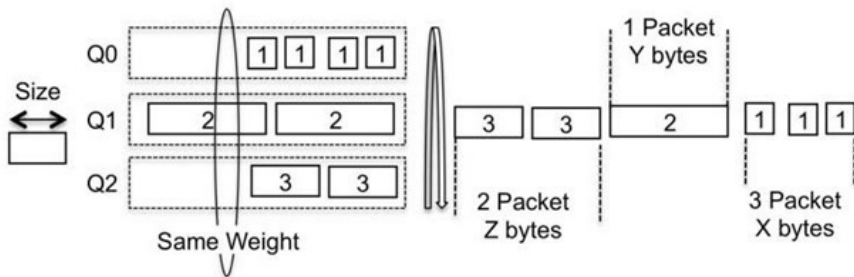
Weighted round robin I
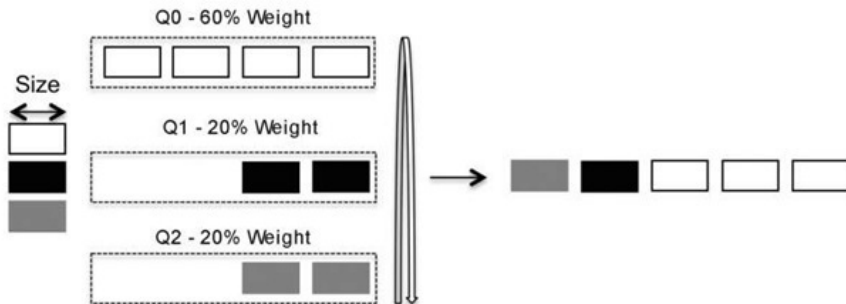
Weighted round robin II

Deficit weighted round robin

50% Weight - Quantum 1000

Q0 | 300 | 500 | 300 |

Size

(300)

25% Weight - Quantum 500

Q1 | 1000 | 1000 |

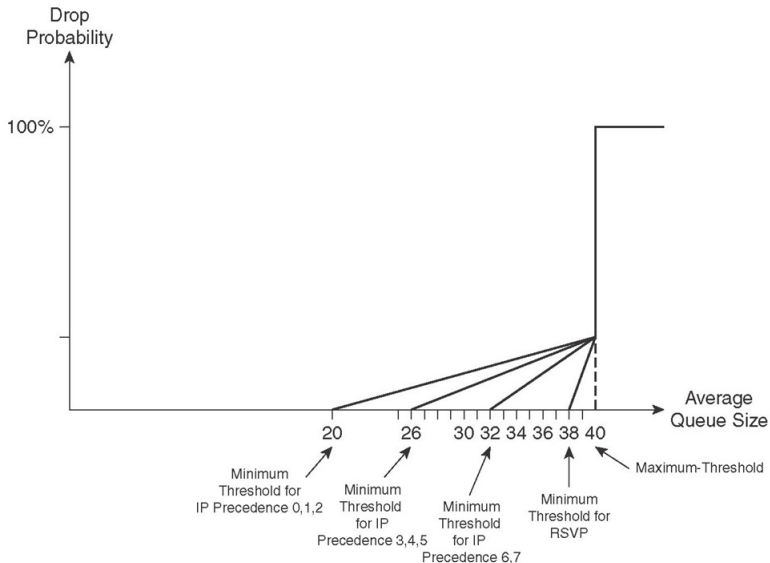25% Weight - Quantum 500

Q2 | 300 | 300 |

Network Congestion

- congestion
    - ▶ sharp increase in the loss rate
    - ▶ degradation of network parameters
- prevention (congestion avoidance)
    - ▶ bandwidth reservation for certain connections
    - ▶ reaction for signs of congestion – increased delay, packet dropping (TCP)
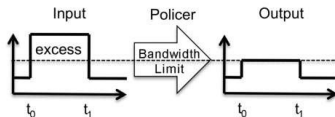
RED – random early detection
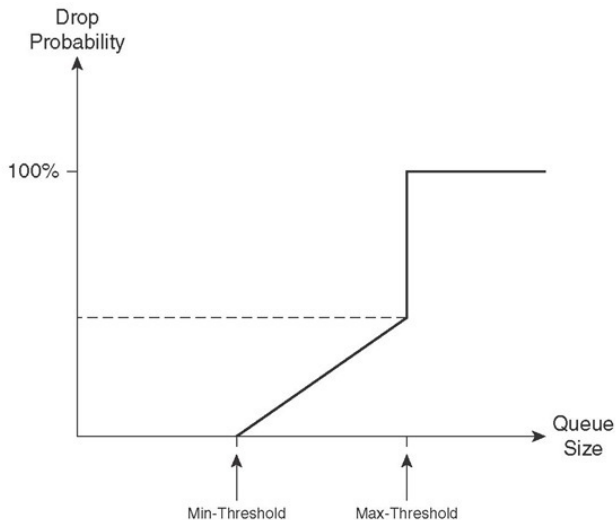
WRED – weighted random early detection

Policing & shaping: deal with burstiness and excess traffic
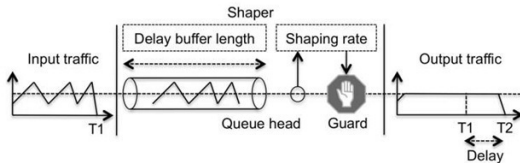
- policier, input parameters:
    - ▶ bandwidth limit
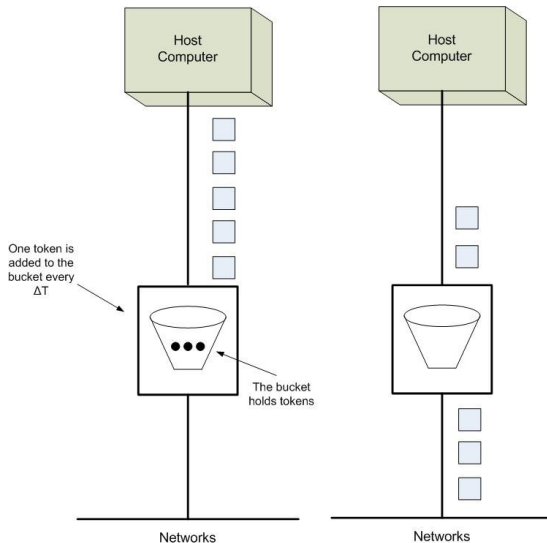   - ▶ burst size limit
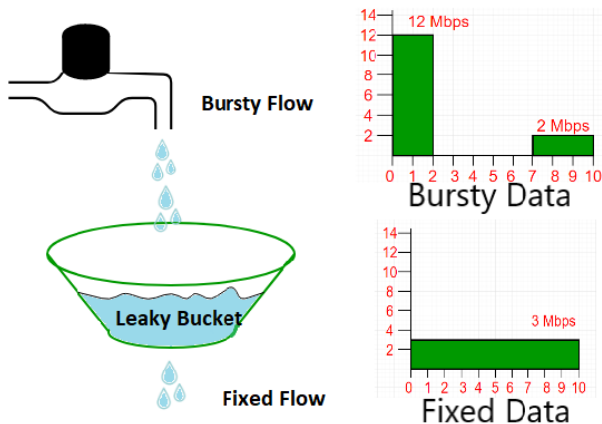

- sharper, input parameters:
    - ▶ shaping rate
    - ▶ delay buffer length

Token bucket

Leaky bucket

Source: https://www.geeksforgeeks.org