Exercises and Solutions – Chapter 2: Quality of Service (QoS)

Section 1 – Understanding the Need for QoS

Exercise 1

Question: Explain why Quality of Service (QoS) is necessary in IP networks and identify three main causes of quality issues.

Solution: QoS is necessary because IP networks traditionally use a best-effort delivery model, which does not guarantee delay, jitter, or packet loss performance.

Three main causes of quality issues:

1. Lack of bandwidth – when network capacity is insufficient for the traffic demand.
2. Latency and jitter – high or variable delay across the network path.
3. Packet loss – dropped packets due to congestion or buffer overflow.

Section 2 – QoS Principles

Exercise 2

Question: List and explain the four main principles for providing QoS guarantees in IP networks.

Solution:

1. Principle 1 – Classification and Prioritization: Mark packets and assign different priorities (e.g., give audio higher priority over FTP).

2. Principle 2 – Policing and Isolation: Ensure sources adhere to their declared bandwidth; prevent one flow from affecting another.

3. Principle 3 – Efficient Resource Utilization: Share resources dynamically instead of fixed allocations to avoid underutilization.

4. Principle 4 – Call Admission Control: Admit new flows only if sufficient resources are available; otherwise, reject the request.

Section 3 – Delay and Bandwidth Calculations

Exercise 3

Question: A 1000-byte packet is sent over a 2 Mbps link. Calculate the serialization delay.

Solution:

Serialization Delay = (Packet Size × 8) / Link Speed = (1000 × 8) / (2 × 10^6) = 0.004 seconds = 4 ms.

Exercise 4

Question: If the ITU G.114 recommends a maximum one-way latency of 150 ms for real-time traffic, and propagation + processing delays total 120 ms, what is the maximum allowable queueing delay?

Solution: Maximum queueing delay = 150 - 120 = 30 ms.

Section 4 – Leaky Bucket Policing

Exercise 5

Question: In a leaky bucket algorithm, the bucket size b = 10 tokens, and tokens are generated at a rate r = 5 tokens/sec. What is the maximum number of packets that can be sent in 4 seconds?

Solution: Maximum packets = $r \times t + b = 5 \times 4 + 10 = 30$ packets.

Section 5 – QoS Models

Exercise 6

Question: Differentiate between IntServ, DiffServ, and Best-Effort QoS models.

Solution:

- Best-Effort: No QoS; all packets treated equally. Example: email, web.
- IntServ: Per-flow resource reservation using RSVP. Example: video conferencing.
- DiffServ: Traffic classified into classes; per-class QoS. Example: enterprise networks.

Section 6 – IntServ Mechanisms

Exercise 7

Question: In IntServ, what are the roles of TSpec and RSpec?

Solution:

- TSpec (Traffic Specification): Describes the flow's traffic characteristics (rate, burst size, peak rate).
- RSpec (Reservation Specification): Describes the service guarantees required (reserved bandwidth, delay bound).

Exercise 8

Question: Describe the steps in RSVP signaling for IntServ.

Solution:

1. PATH message (Sender → Receiver): carries TSpec.
2. RESV message (Receiver → Sender): carries RSpec.
3. Routers reserve resources if available.
4. Refresh messages maintain the reservation.
5. Tear Down messages release resources.

Section 7 – DiffServ Mechanisms

Exercise 9

Question: Explain the difference between Edge Router and Core Router functions in DiffServ.

Solution:

- Edge Router: Performs classification, marking, and conditioning of packets based on DSCP values.
- Core Router: Uses Per-Hop Behaviors (PHBs) like EF or AF for scheduling and forwarding.

Exercise 10

Question: A DSCP PHB name of CS4 has what equivalent decimal value? A DSCP decimal value of 20 corresponds to which PHB name?

Solution:

- CS4 → Decimal 32
- Decimal 20 → PHB AF22.