# QoS (Quality of Service)

**1. Purpose of QoS:**

* Ensures high-quality delivery of applications like voice and video.
* Addresses congestion and prioritizes traffic to meet quality expectations.

**2. Congestion:**

* Occurs when multiple data streams converge on a single device or interface.
* Can be due to high traffic volume or large data packets blocking smaller ones.
* Leads to delays and packet loss as devices queue packets.

**3. Prioritizing Traffic:**

* Traffic classified into queues: High, Medium, and Low priority.
* Examples:
  + VoIP traffic: High priority
  + Financial transactions: Medium priority
  + Web data: Low priority
* Routers manage queues to prioritize traffic and prevent any single type from consuming all bandwidth.

**4. Bandwidth, Congestion, Delay, and Jitter:**

* **Bandwidth:** Measured in bits per second (bps). Example: 10 Gbps.
* **Congestion Points:** Examples include switch aggregation, speed mismatch, LAN to WAN link.
* **Delay Types:**
  + **Code delay:** Time to compress data.
  + **Packetization delay:** Time to encapsulate a packet.
  + **Queuing delay:** Time a packet waits in queue.
  + **Serialization delay:** Time to put data on the wire.
  + **Propagation delay:** Time for data to travel across the network.
  + **De-jitter delay:** Time to buffer and evenly space packets.
* **Jitter:** Variation in packet delay affecting real-time traffic quality.

**5. Packet Loss:**

* Occurs when packets are dropped due to congestion.
* Affects time-sensitive packets (e.g., VoIP) and can cause quality issues.
* **Playout Delay Buffer:** Compensates for jitter by buffering packets and sending them out at consistent intervals.
* Excessive jitter can cause packet drops, leading to audio problems in VoIP.

**6. QoS Mechanisms:**

* Classify and prioritize traffic to ensure minimal packet loss and delay.
* Guarantee bandwidth for critical traffic like voice and video.

# Traffic Characteristics

**Network Traffic Trends Notes**

**1. Traffic Types:**

* **Voice Traffic:**
  + Predictable bandwidth needs.
  + Sensitive to delays and packet loss.
  + Requires high priority; tolerates latency (≤ 150 ms), jitter (≤ 30 ms), and packet loss (≤ 1%).
  + Bandwidth: 30-128 Kbps.
* **Video Traffic:**
  + Increasingly important; less predictable, more data-intensive.
  + Degrades without QoS and extra bandwidth (blurry, unsynchronized).
  + Variable packet sizes and rates; requires high priority.
  + Tolerates latency (≤ 400 ms), jitter (≤ 50 ms), and packet loss (≤ 1%).
  + Bandwidth: 384 Kbps to > 20 Mbps.
* **Data Traffic:**
  + Uses TCP (error recovery) or UDP.
  + Can be smooth or bursty; TCP ensures retransmission.
  + Less sensitive to drops and delays compared to voice and video.
  + Factors to consider:
    - **Interactive:** Prioritize for low delay (1-2 seconds response time).
    - **Not Interactive:** Delay can vary; gets leftover bandwidth after priority traffic needs are met.

**2. Summary of Traffic Characteristics:**

* **Voice:**
  + Smooth, delay-sensitive, drop-sensitive.
  + UDP priority.
  + Latency: ≤ 150 ms
  + Jitter: ≤ 30 ms
  + Loss: ≤ 1%
* **Video:**
  + Bursty, delay-sensitive, drop-sensitive.
  + UDP priority.
  + Latency: ≤ 200-400 ms
  + Jitter: ≤ 30-50 ms
  + Loss: ≤ 0.1-1%
* **Data:**
  + Smooth/bursty, delay-insensitive, drop-insensitive.
  + TCP handles retransmissions.
  + Bandwidth consumption varies.

**3. Trends:**

* Video traffic will represent 82% of internet traffic by 2022.
* Mobile video traffic expected to reach 60.9 exabytes per month by 2022.

## Integrated Services (IntServ)

* **Purpose:** Ensures high QoS with guaranteed delivery.
* **Mechanism:** Uses resource reservation and admission control.
* **Key Features:**
  + Explicit end-to-end resource reservation.
  + Requires signaling (RSVP) for QoS requests.
  + **Scalability:** Limited; resource-intensive due to per-flow state management.
* **Benefits:**
  + Guarantees bandwidth, delay, and packet-loss rates.
  + Suitable for applications needing hard QoS (e.g., real-time video).
* **Drawbacks:**
  + Not scalable for large networks like the internet.
  + High resource consumption for continuous signaling and state maintenance.

## Differentiated Services (DiffServ)

* **Purpose:** Provides scalable and flexible QoS with class-based traffic management.
* **Mechanism:** Classifies traffic into different classes with varying QoS levels.
* **Key Features:**
  + No end-to-end signaling; uses “soft QoS” approach.
  + Traffic is classified and prioritized on a per-hop basis.
  + **Scalability:** High; minimal per-flow state management.
* **Benefits:**
  + Highly scalable and cost-effective.
  + Supports multiple levels of service for different traffic classes.
* **Drawbacks:**
  + No absolute end-to-end guarantee of service quality.
  + Requires complex QoS mechanisms across the network

**Which QoS model provides per-request policy admission control?**

* **Integrated Services (IntServ)**: Provides per-request policy admission control by reserving resources for each individual traffic flow and using signaling (RSVP).

**Which QoS model requires no special QoS mechanisms?**

* **Best-Effort Model**: Does not implement any QoS mechanisms; all traffic is treated equally with no preferential treatment.

**Which QoS model provides many different levels of quality?**

* **Differentiated Services (DiffServ)**: Provides multiple levels of service quality by classifying and managing traffic into various classes.

**Which QoS model uses explicit end-to-end resource admission control?**

* **Integrated Services (IntServ)**: Uses explicit end-to-end resource reservation and admission control to ensure QoS for each flow.

**Which QoS model is the most scalable?**

* **Differentiated Services (DiffServ)**: Highly scalable by classifying traffic into broad classes and applying QoS policies on a per-hop basis, minimizing per-flow state management.