# Network performance

# Performance is more than speed

| Measure | Meaning | Effect |
|---|---|---|
| **Bandwidth** | The theoretical capacity of a link per unit time | Limits possible transfer rate |
| **Throughput** | The actual rate achieved | Determines how quickly useful data arrives |
| **Latency** | Delay between sending and receiving | Makes interaction feel slow |
| **Jitter** | Variation in packet delay | Disrupts real-time audio and video |
| **Packet loss** | Packets fail to reach the destination | Causes gaps or retransmission |

> **Key idea:** A high-bandwidth link can still feel unresponsive when latency is high. Different applications value different performance characteristics.

## Match the evidence

**Determine** the main issue in each case.

1. A 100 Mbps link transfers at 42 Mbps.
2. Video-call packets arrive at irregular intervals.
3. A button response takes 600 ms even though the message is tiny.
4. Some voice packets never arrive.

**Check your answer**

1. Throughput is below bandwidth.
2. Jitter.
3. Latency.
4. Packet loss.

# Calculate transfer time carefully

Use compatible units and distinguish bits from bytes.

```
transfer time (seconds) = data size (bits) / throughput (bits per second)
```

A 20 megabyte file contains approximately 160 megabits. At an actual throughput of 40 megabits per second, the idealised transfer time is:

```
160 Mb / 40 Mb/s = 4 seconds
```

Real transfers may take longer because of protocol overhead, changing conditions, competing traffic and retransmissions.

## Calculate a transfer

A 75 MB video transfers at 30 Mbps. **Determine** the idealised time.

**Check your answer**

`75 MB × 8 = 600 Mb`; `600 / 30 = 20 seconds`.

# Packet switching

Packet switching divides data into packets that can travel through a shared network. Each packet carries control information used to deliver and reassemble the data.

1. The sender divides and labels the data.
2. Network devices forward packets towards the destination.
3. Packets may take different routes or arrive out of order.
4. The receiver checks and reassembles them.
5. Missing or damaged data may be recovered according to the protocol.

Sharing links improves network use, but variable routes and congestion can change delay and loss.

# Routing and forwarding

- **Routing** determines paths and maintains information about how networks can be reached.
- **Forwarding** is the local action of moving an arriving packet to the appropriate outgoing interface.

A route may change when a link fails or another path becomes preferable. More hops do not automatically prove poor performance; link quality, distance, load and processing also matter.

## Explain the relationship

**Explain** how routing and forwarding work together.

**Check your answer**

Routing creates or updates knowledge about reachable paths. A router then uses that knowledge when forwarding each packet to its next hop. Routing informs the decision; forwarding performs it.

# Congestion and flow control

**Congestion** occurs when offered traffic exceeds the capacity of network resources. Queues grow, latency rises and buffers may discard packets.

**Congestion control** adjusts sending behaviour in response to network conditions. **Flow control** prevents a sender from overwhelming the receiving endpoint's ability to process data.

> **Diagnose before upgrading:** adding bandwidth may help a saturated link, but it will not remove propagation delay, fix a failing server or correct an inefficient database query.

## Read a performance pattern

| Time | Throughput | Latency | Loss |
|---|---|---|---|
| 10:00 | 82 Mbps | 24 ms | 0% |
| 12:30 | 18 Mbps | 310 ms | 6% |

**Analyse** the likely change at 12:30.

**View a sample solution**

The combination of reduced throughput, sharply increased latency and packet loss is consistent with congestion or another serious link-quality problem at 12:30. More evidence is needed to locate the cause.

# Error detection and correction

Transmission systems use error-control processes to detect corrupted or missing data and respond appropriately.

- A checksum or other integrity check can reveal changed data.
- Sequence information can reveal missing or reordered segments.
- Acknowledgments confirm receipt.
- Retransmission replaces missing or damaged data.
- Some systems use forward error correction to recover certain errors without retransmission.

Retransmission supports reliability but consumes capacity and adds delay. Real-time media may prefer a small gap over waiting for a late packet.

# TCP, UDP and application needs

| Transport | Useful characteristics | Typical priority |
|---|---|---|

| | | |
|---|---|---|
| TCP | Connection-oriented, ordered reliable byte stream with flow and congestion control | Complete, ordered delivery |
| UDP | Connectionless datagrams with low transport overhead and no built-in delivery guarantee | Timeliness or application-controlled recovery |

Applications may add their own reliability or security. “UDP is always faster” is too broad; suitability depends on implementation and purpose.

# Quality of service

Quality of service (QoS) mechanisms classify and manage traffic so important flows receive appropriate treatment during contention.

- Prioritise delay-sensitive voice over a background software download.
- Reserve or shape traffic to protect essential services.
- Manage queues to reduce delay and loss for selected classes.

QoS manages limited capacity; it does not create unlimited bandwidth. Prioritising one class may delay another, so priorities must reflect actual requirements.

## Choose a priority

A hospital link carries a live remote consultation and a scheduled archive backup. **Recommend** a QoS priority and **Explain** the trade-off.

**Check your answer**

Prioritise the real-time consultation because latency, jitter and loss directly affect communication needed now. Shape or schedule the backup with lower priority; it may finish later but its complete data can still be transferred reliably.

# Evaluate with application criteria

Use the required task to judge measurements.

| Application | Especially important |
| --- | --- |
| Video call | Low latency, jitter and loss; adequate throughput |
| Large backup | Sustained throughput and reliable complete delivery |
| Emergency alert | Low delay, reliable delivery and availability |
| Interactive game | Low latency and jitter |

# Independent practice: community event network

A temporary event network supports payment terminals, a live stream and overnight photo uploads. At peak time, measurements show 95% link utilisation, latency rising from 28 ms to 420 ms, 4% packet loss and highly variable video delay. Payments sometimes time out.

1. **Analyse** the evidence to identify the likely performance condition.
2. **Explain** how it affects payments and live video differently.
3. **Recommend** two refinements, including one QoS decision.
4. **Evaluate** the claim: “The only solution is to increase bandwidth.”

**View a sample solution**

1. Very high utilisation with rising latency, loss and variable delay strongly indicates congestion.
2. Payment requests may time out and retry, risking delay or duplicates; live video suffers from jitter, gaps and reduced quality.
3. Prioritise small payment traffic and delay-tolerant control traffic appropriately, while shaping or scheduling photo uploads outside peak time. Additional capacity may also help if monitoring confirms sustained saturation.
4. The claim is too absolute. More bandwidth could reduce saturation, but traffic scheduling and QoS address competing priorities, and client/server timeout or duplicate-handling problems may also need refinement.

Revision #5
Created 2026-10-06 00:40:32 UTC by Mr Napper
Updated 2026-10-06 01:32:26 UTC by Mr Napper