

Communication modes in networks

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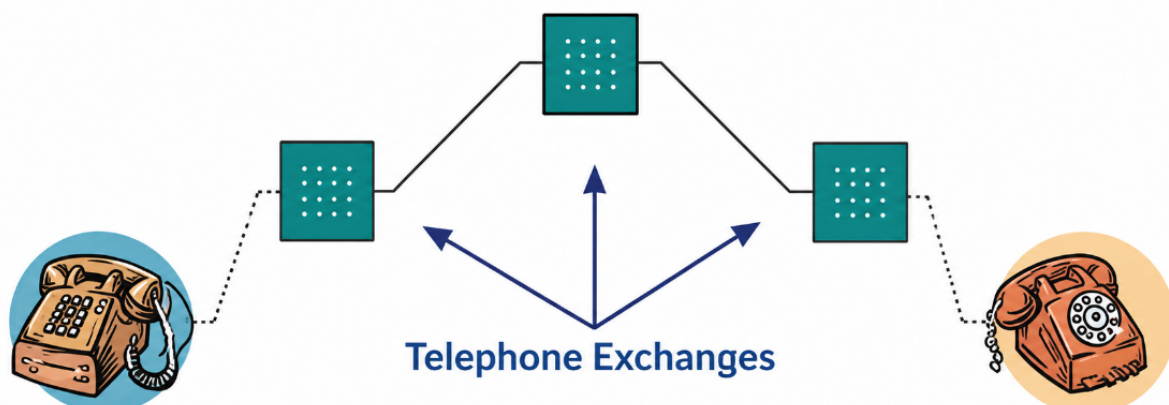
After examining the main physical devices in a network, we can consider how data is actually transmitted.

Networks can use different communication methods, meaning different ways of connecting devices and transmitting information (Kurose & Ross, 2026; Tanenbaum et al., 2021).

Circuit switching

Circuit switching is typically associated with connection-oriented communication because a dedicated path is established before data is exchanged. This occurs, for example, in telephone communication, where a temporary circuit connects the two callers through a series of connections from one telephone exchange to the next (Kurose & Ross, 2026; Tanenbaum et al., 2021).

The transmission resources, such as telephone equipment, lines, and portions of telephone exchanges, remain allocated to the two callers until the call ends (Kurose & Ross, 2026).



Connection-oriented services use transmission resources inefficiently because, when the two callers are not transmitting any signal—for example, when they are silent—the reserved resources remain unused (Kurose & Ross, 2026).

Example

Suppose there are two telephones, one in city A and the other in city B, and we want to establish a direct telephone call between them using circuit switching:

- Initialization: when the user in city A dials the telephone number in city B, the circuit-switching system at A's local telephone exchange detects the call request and reserves a dedicated connection for communication between A and B.

- Connection: telephone exchange A establishes a physical or virtual connection, called a circuit, through the telecommunications network to the telephone exchange in city B. During this phase, resources and communication channels are reserved for the entire duration of the call.
- Communication: once the connection has been established, the users in cities A and B can begin speaking and listening to one another. Because a dedicated connection has been established, voice data is transmitted continuously and without interruption, providing real-time communication between the two users.
- Termination: when one of the users hangs up or ends the call, the circuit-switching system releases the dedicated connection, freeing the network resources that had been reserved for that call.

Packet switching

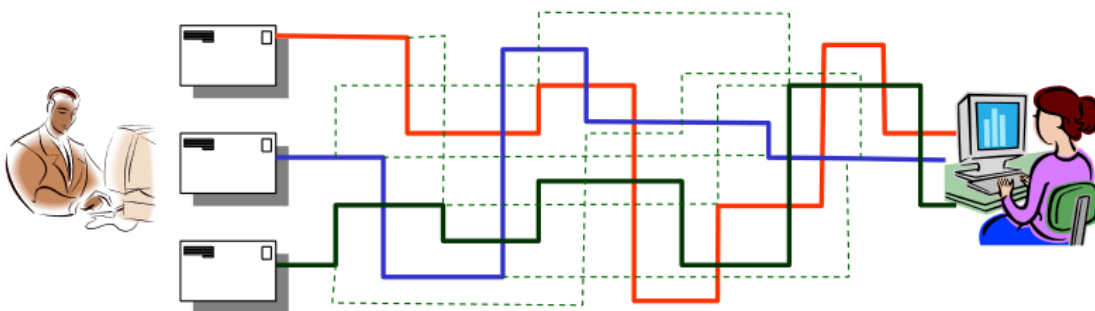
Packet switching can operate without establishing a dedicated path in advance: packets are entrusted to the network and may follow different routes (Kurose & Ross, 2026; Tanenbaum et al., 2021).

The information to be sent is divided into data packets and passed to the network together with the recipient's address, much like items sent through the postal system.

The network is responsible for carrying and routing each packet to its destination.

Unlike circuit switching, packet switching:

- Uses transmission resources more efficiently because they are allocated to a user only for the time required to transmit the packets and are then made available to another user (Kurose & Ross, 2026).
- Does not guarantee a minimum delivery time or the exact order in which packets will arrive: the network simply attempts to provide a “best-effort” service (Postel, 1981).



Packet switching is highly flexible and efficient, but it can introduce variable delays (Kurose & Ross, 2026).

For this reason, real-time applications such as Internet calls, video conferences, and online games require specific protocols and techniques to reduce delays and interruptions (Kurose & Ross, 2026).

For example, when receiving a file or an email, the user may not notice a delay. In a real-time event such as a telephone call, however, even a one-second delay is noticeable to both participants.

The Internet uses packet switching: data is divided into packets and forwarded through the network. Some protocols add controls to manage packet order, errors, and reliability (Kurose & Ross, 2026; Postel, 1981).

Example

Suppose you want to send an email containing a text message and several images to a friend. Using packet switching, the process might work as follows:

- Packetization: the text message and images are divided into small data packets. For example, the text message may be split into several packets, as may each image.
- Routing: the packets are routed through the network. During this process, each packet may follow a different route to the destination because it can be directed along the most efficient path available at that moment.
- Transmission: the packets travel across the network and pass through several routers along the way. Each network device forwards them to the next node according to the routing information needed to reach the destination.
- Arrival at the destination: once the packets reach their destination, they are processed. The communication protocols check the received data and reconstruct the original message. The packets are then reassembled to recreate the original email, including its text and images.
- Viewing the message: your friend receives the email, opens the attachment, and sees the text and images as they were sent.

Types of Transmission Channels

Two types of transmission channels are widely used:

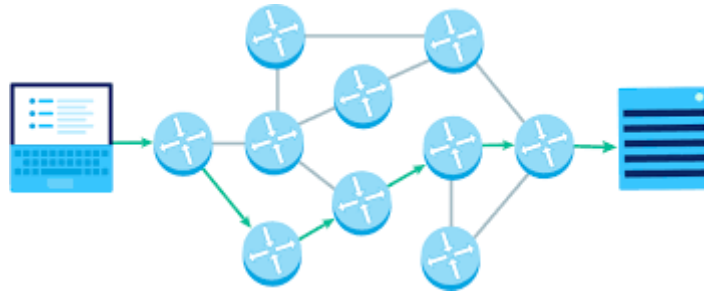
- Point-to-point connections.
- Broadcast.

Point-to-point connections, also called unicast connections, connect pairs of computers (Tanenbaum et al., 2021).

In a network made up of point-to-point connections, packets may have to pass through one or more intermediate machines to travel from the source to the destination.

Individual point-to-point connections are called **links**.

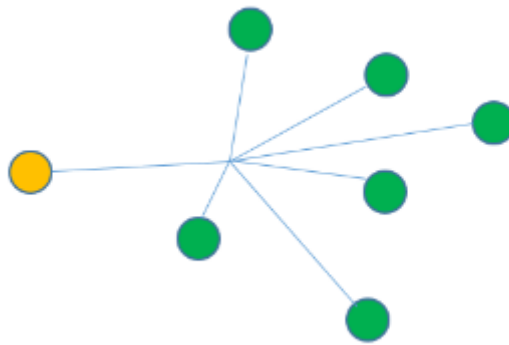
In its most basic sense, a link is a direct communication line between two nodes.



A set of links connecting a client to a server

By contrast, a broadcast network has a single communication channel shared by all the machines in the network: packets sent by any machine are received by every machine on the network (Tanenbaum et al., 2021).

When a message is received, each machine checks its address field. If the address matches that machine, the message is processed; otherwise, it is ignored (Tanenbaum et al., 2021).



The yellow node is the server, and the green nodes are the clients

Supplementary materials

Key points

- **Circuit switching** creates a dedicated path between the sender and the recipient for the entire duration of the communication.
- Resources remain reserved even when they are not being used, making the system less efficient.
- **Packet switching** divides data into packets that may follow different paths through the network.
- Resources are used only during transmission, improving efficiency.
- The network operates according to the **best-effort principle**: it does not guarantee delivery times, packet arrival order, or the absence of delays.
- The Internet uses packet switching; protocols can manage errors, packet order, and data reassembly.
- **In point-to-point or unicast connections**, each link directly connects two nodes.
- **In broadcast networks**, all devices receive the packet, but only the specified recipient processes it.

Exercises

A Line That Is Always Reserved

Two company offices need to communicate for one hour. Before communication begins, the system establishes a dedicated path between the two offices and keeps the necessary resources reserved until the end of the session.

During the hour-long connection, however, no data is transmitted for several minutes.

Answer the following questions:

- Identify which switching method is being used and justify your answer.
- Describe the initialization, connection, communication, and termination phases.
- Explain what happens to the network resources during the periods when the two offices are not transmitting data.
- Explain why this method can result in inefficient use of transmission resources.
- Indicate what advantage having a dedicated path can nevertheless provide during communication.

Ten Users Have to Share the Same Network

A network is used simultaneously by ten users. Each user transmits data only for short periods and remains inactive most of the time.

Two solutions are proposed:

- Solution A: reserve part of the resources for each user for the entire duration of the connection.
- Solution B: use the resources only when a user actually needs to transmit packets, then make them available to the other users.

Analyze the two solutions.

- Associate each solution with circuit switching or packet switching.
- Explain which of the two generally uses resources more efficiently in the situation described.
- Explain what happens in Solution A when a user remains inactive.
- Explain how resources can instead be shared in Solution B.
- Indicate which solution may result in greater variability in delays.
- Choose the solution you consider most suitable for this case and justify your answer.

A Message Travels Across the Internet

You need to send a friend an email containing text and some images. The message is transmitted across the Internet using packet switching.

Reconstruct what happens.

- Explain why the content of the email is divided into multiple packets.
- Identify which information allows the network to determine the destination of the packets.
- Explain why packets belonging to the same message may follow different paths.
- Describe the function performed by the routers encountered along the way.
- Explain why packets may not necessarily arrive in the same order in which they were sent.
- Describe what must happen at the destination so that the user can view the complete message again.
- Finally, reconstruct the entire process using the sequence division → routing → transmission → arrival → reassembly.

Download and Videoconference

A student is simultaneously:

- Downloading a large file.
- Participating in a videoconference.

In both cases, the data travels through a packet-switched network. At a certain point, the network becomes congested and some packets experience variable delays.

Answer the following questions:

- Explain why the delay may be barely noticeable during the file download but very noticeable during the videoconference.
- Explain what it means for a packet-switched network to operate according to a best-effort model.
- Explain why the network does not necessarily guarantee a maximum delivery time for each packet.
- Identify which of the two applications is more sensitive to delays and justify your answer.
- Imagine that some packets arrive out of order. Explain why this behavior is compatible with the packet-switching model described in the learning material.
- Explain why real-time applications such as videoconferencing, Internet calls, and online video games require particular attention to delay management.

Reconstructing a Point-to-Point Path

Computer A needs to send data to Server B. The two devices are not directly connected, but several intermediate devices exist between them.

The path followed is:

Computer A → Router 1 → Router 2 → Router 3 → Server B

Analyze the communication.

- Identify how many direct connections, or links, make up the path shown.
- Explain what is meant by a point-to-point link.
- Explain why Computer A and Server B can communicate even though they do not have a direct connection between them.
- Describe what must happen to a packet in order to travel from the source to the destination.
- Imagine that an alternative path also exists through Router 4 and Router 5. Explain why, in a packet-switched network, different packets could theoretically reach the same server through different paths.
- Explain the difference between a single link and the complete path made up of multiple links.

A Message for Everyone, but Intended for Only One Device

In a small network, a single communication channel is shared by all devices.

Computer A sends a packet intended for Computer D. Computers B, C, and E also receive the packet through the shared channel.

Answer the following questions:

- Identify which type of transmission channel is being used.
- Explain why B, C, and E also receive the packet.
- Identify which information the devices must check when they receive the packet.
- Explain what Computer D must do after verifying that the packet is addressed to it.
- Explain what B, C, and E must do instead.
- Compare this method with a network based on point-to-point links.

Another student states: "If everyone receives the packet, then everyone must necessarily process its contents."

Evaluate the statement and explain the error using the operation of broadcast networks described in the learning material.

Bibliography

Kurose, J. F., & Ross, K. W. (2026). *Computer networking: A top-down approach* (9th ed.). Pearson.

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Postel, J. (1981). *Internet protocol (RFC 791)*. RFC Editor.

<https://doi.org/10.17487/RFC0791>

Tanenbaum, A. S., Feamster, N., & Wetherall, D. J. (2021). *Computer networks* (6th ed.). Pearson.

<https://www.pearson.com/en-us/subject-catalog/p/computer-networks/P200000003188/9780137523214>

Further reading

- James F. Kurose and Keith W. Ross, Computer Networking: A Top-Down Approach, 9th ed., Pearson, 2026 — Provides a particularly clear comparison between packet switching and circuit switching and explains how packets move through the network core, including routing, queuing, delay, packet loss, throughput, and the best-effort model used by the Internet.
- Andrew S. Tanenbaum, Nick Feamster, and David J. Wetherall, Computer Networks, 6th ed., Pearson, 2022 — Offers a systematic treatment of communication technologies and network architectures, helping to deepen the distinction between point-to-point and broadcast networks, shared communication channels, packet-switched networks, and the mechanisms used to move data between interconnected devices.
- Behrouz A. Forouzan, Data Communications and Networking with TCP/IP Protocol Suite, 6th ed., McGraw Hill, 2022 — Explains the foundations of data communication through a bottom-up approach and covers LANs, WANs, connecting devices, data transfer, routing, and the TCP/IP architecture, making it useful for understanding how different communication and switching methods fit into complete networks.
- Larry L. Peterson and Bruce S. Davie, *Computer Networks: A Systems Approach*, 6th ed., Morgan Kaufmann, 2021 — Explores packet-based communication from a systems perspective, showing how links, switches, routers, internetworking, congestion control, and resource allocation interact to create end-to-end communication across a network.
- William Stallings, Data and Computer Communications, 10th ed., Pearson, 2022 — Provides a broader telecommunications perspective on data networks, with particular attention to communication models, wide-area and local-area networks, switching technologies, network performance, and the principles underlying the transmission of data across shared and interconnected networks.

Editorial notes

In producing these materials, I have used generative artificial intelligence tools to support the writing process, particularly to improve the form of the text, reorganize content, refine wording, and speed up certain editorial tasks.

As I work independently on the production of these materials, I try to automate any activities that can reasonably be automated, so that I can devote more time to research, design, and content development.

However, artificial intelligence does not determine the content of this work: the choice of topics, structure, ideas, interpretations, examples, and teaching approach are developed by me. AI is therefore used primarily as a tool to support production and formal revision, while authorship and responsibility for the design and content remain mine.

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