Network types

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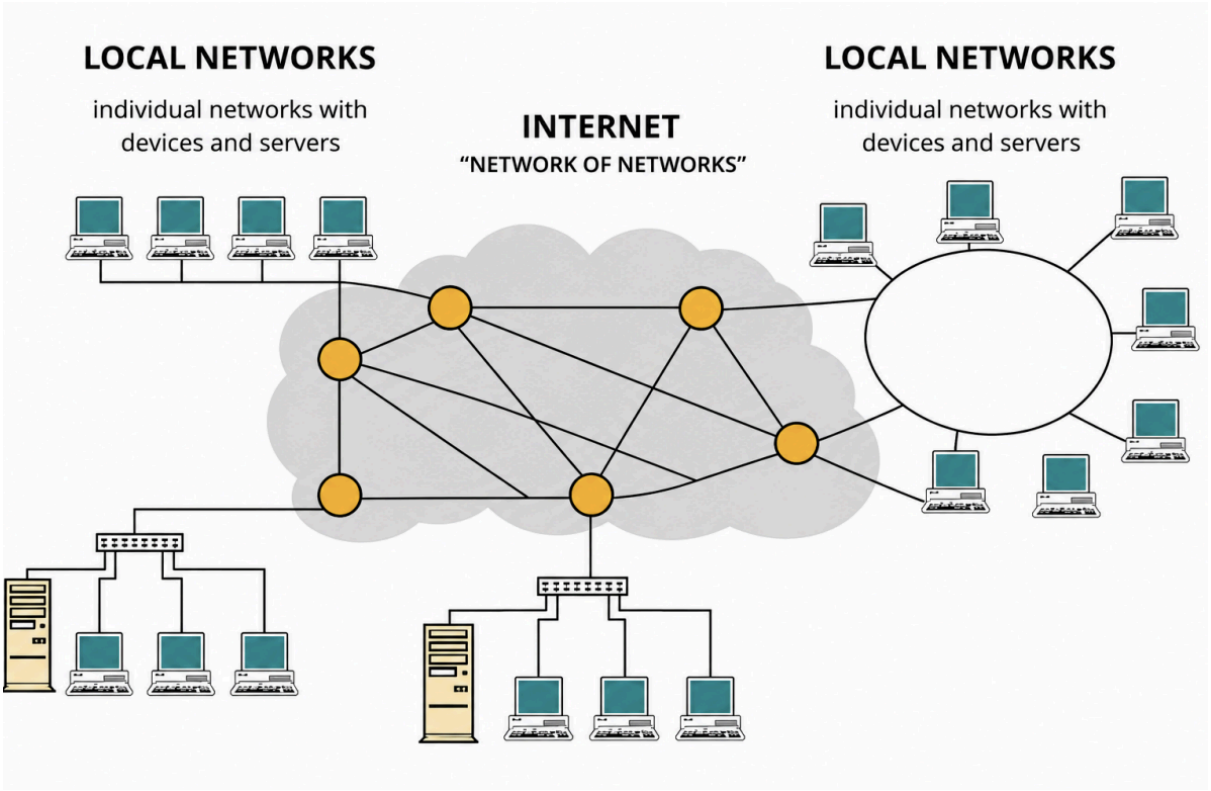
An important criterion for classifying networks is their scale, since networks of different sizes use different technologies (Tanenbaum et al., 2021).
Based on their scale, we can distinguish:

- *PAN*, Personal Area Network: a personal network used to connect devices located very close to the user, such as smartphones, Bluetooth headphones, smartwatches, mice, or keyboards.
- *LAN*, Local Area Network: a local network used in a home, laboratory, office, school, or building.
- *WAN*, Wide Area Network: a wide geographical network used to connect networks distributed over long distances, for example across cities, countries, or continents.

The table below provides a summary. The distances shown are approximate values: they help illustrate the scale of the networks, although in practice the boundaries between different network types may vary depending on the technology and context (Tanenbaum et al., 2021).

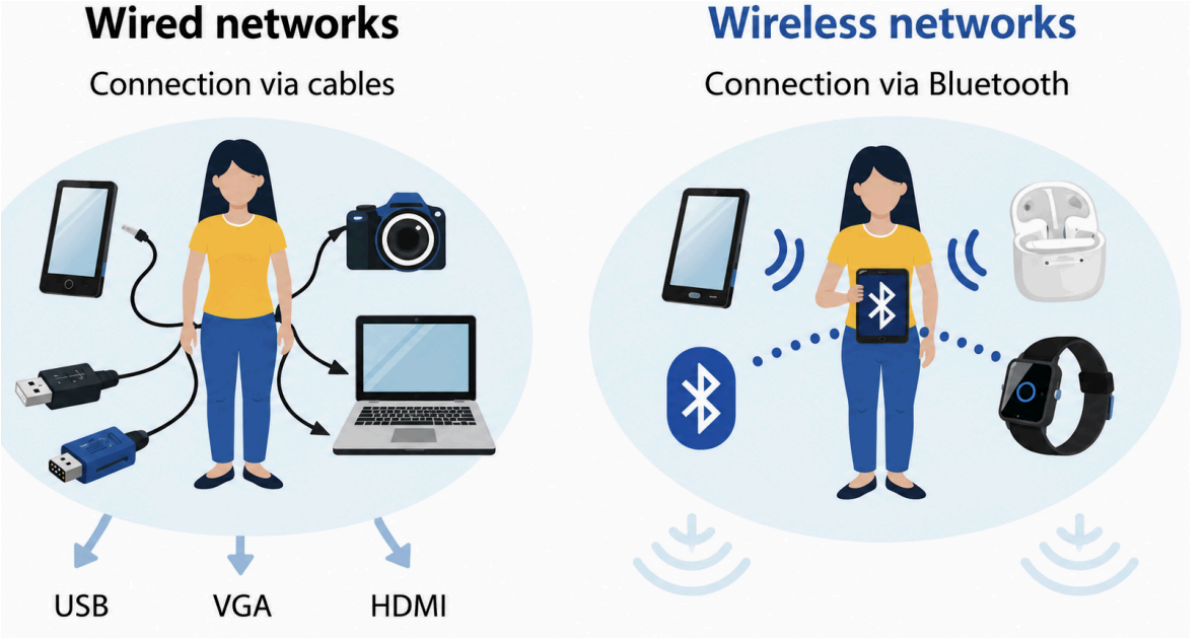
Distance Between Devices	Example Area	Technology
1 m	Square meter	Personal area network (*PAN*)
10 m	Room	Local area Network (*LAN*)
100 m	Building	Local area Network (*LAN)*
1 km	Campus	Local area Network (*LAN*)
10 km	City	Wide area network (*WAN*)
100 km	Country	Wide area network (*WAN*)
1.000 km	Continent	Wide area network (*WAN*)
10.000 km	Planet	Internet

The connection of two or more networks is called an **internetwork** or **internet**, with a lowercase i. (Tanenbaum et al., 2021).
The worldwide Internet, with an uppercase I, is a particular internet that connects the entire globe (Kurose & Ross, 2026; Tanenbaum et al., 2021).
The Internet is certainly the best-known example of an internetwork because it is a vast global network of interconnected devices that enables communication, information exchange, and access to online resources and services.
Essentially, the Internet is a network of networks in which millions of devices and servers around the world are connected, allowing data to be shared and transferred.



PAN

PANs (Personal Area Networks) allow devices to communicate within the physical space surrounding a person (Tanenbaum et al., 2021).
PANs can be wired or wireless.
A wired PAN can connect nearby devices using cables, such as USB. A wireless PAN, by contrast, connects devices without cables, for example through Bluetooth (Tanenbaum et al., 2021).



Bluetooth

Bluetooth is a short-range wireless communication standard that enables the transmission of data and audio signals between devices such as smartphones, computers, tablets, headphones, speakers, and other electronic devices (Bluetooth SIG, 2025).
Compared with Wi-Fi, the wireless connection used for LANs, Bluetooth is designed for short-range, low-power communication. This means that it transmits at low power, which is sufficient for connecting nearby devices but not intended to cover long distances (Bluetooth SIG, 2025; Kurose & Ross, 2026).

Bluetooth is used in a wide range of devices and applications, including wireless headphones and speakers, wireless mice and keyboards, fitness sensors, remote-control devices, and many others.
Thanks to its ease of use, low power consumption, and security, Bluetooth remains a popular standard for short-range wireless communication.

Differences Between Bluetooth and Wi-Fi:

- Bluetooth is mainly used to connect nearby devices directly, such as headphones, mice, keyboards, smartwatches, or controllers.
- Wi-Fi is mainly used to connect a device to a local network and, through it, to the Internet.
- Wi-Fi is generally faster than Bluetooth and is better suited to transferring large amounts of data.
- Bluetooth consumes less energy and is better suited to small or battery-powered devices.

Bluetooth is designed for short-range connections, whereas Wi-Fi is designed to cover larger areas such as a room, home, laboratory, or office Bluetooth SIG, 2025; Kurose & Ross, 2026).

From the user's perspective, however, using Bluetooth does not simply mean turning it on: the devices must first detect one another, pair, and establish a connection.
Connecting two Bluetooth devices usually involves several steps.

- The first step is to enable Bluetooth: it must be turned on for both devices. For example, to connect wireless headphones to a smartphone, Bluetooth must be active on both the smartphone and the headphones.
- The second step is discovery mode: one device must make itself visible to other nearby devices. For example, when Bluetooth headphones are placed in pairing mode, they become discoverable by the smartphone, which can then find them in the list of available devices.
- The third step is pairing: pairing is the process through which two Bluetooth devices are associated with one another for the first time. During this phase, the devices exchange identification information and, in some cases, the user may be asked to enter a PIN or confirm the connection. For example, when the name of the Bluetooth headphones is selected on the smartphone, the phone starts the pairing process. If pairing is successful, the smartphone stores the headphones among its known devices (Bluetooth SIG, 2025).

Once pairing is complete, the devices can connect. Pairing and connecting are not exactly the same: pairing creates a persistent relationship between two devices, whereas a connection is the active link currently used to exchange data.
For example, Bluetooth headphones may already be paired with a smartphone without being connected. When they are switched on, the smartphone may recognize and connect to them automatically. At that point, audio is sent from the smartphone to the headphones (Bluetooth SIG, 2025).

When a Bluetooth device is no longer needed, it can be disconnected.
Disconnecting interrupts the active link without deleting the pairing. The device therefore remains stored and can reconnect more easily in the future (Bluetooth SIG, 2025).
For example, if Bluetooth headphones are disconnected from a smartphone, audio is no longer played through them, but the smartphone can still remember them. If the headphones are switched on later, they can be reconnected without repeating the entire pairing process.

Unpairing, also called removing or "forgetting" a device, is different.
Unpairing deletes the stored association. After unpairing, the two devices no longer recognize one another automatically. To use them together again, the pairing procedure must be repeated (Bluetooth SIG, 2025).
For example, if "forget this device" is selected for Bluetooth headphones on a smartphone, the phone deletes the pairing information. To use the same headphones with that phone again in the future, they must be placed in pairing mode and paired again.

LAN

A local area network (LAN) connects multiple devices within a limited area, often through switches and access points (Kurose & Ross, 2026; Tanenbaum et al., 2021).

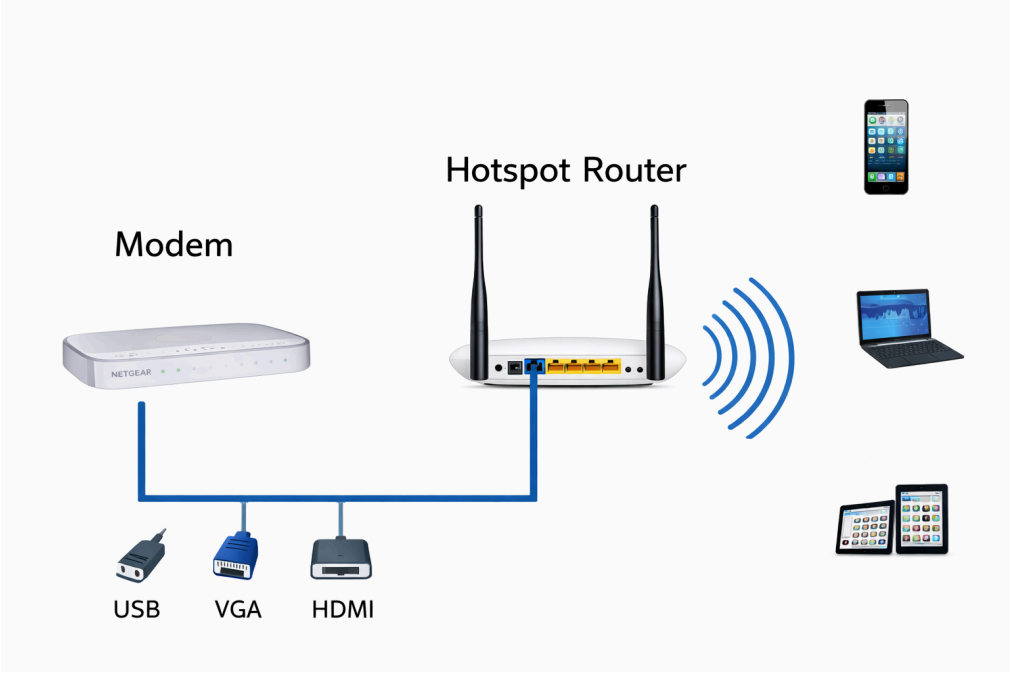
For example, if a home or office contains several computers, printers, and servers that need to communicate, they must be connected through a LAN so that the devices can exchange data.

Within a LAN, devices use MAC addresses to identify one another and exchange data. When a device sends data to another device on the same local network, the control information also includes the recipient's MAC address (Kurose & Ross, 2026).
When a device communicates with another device on the same LAN, it sends the data across the local network. If a switch is present, the switch forwards the data to the correct port based on the recipient's MAC address (Kurose & Ross, 2026).

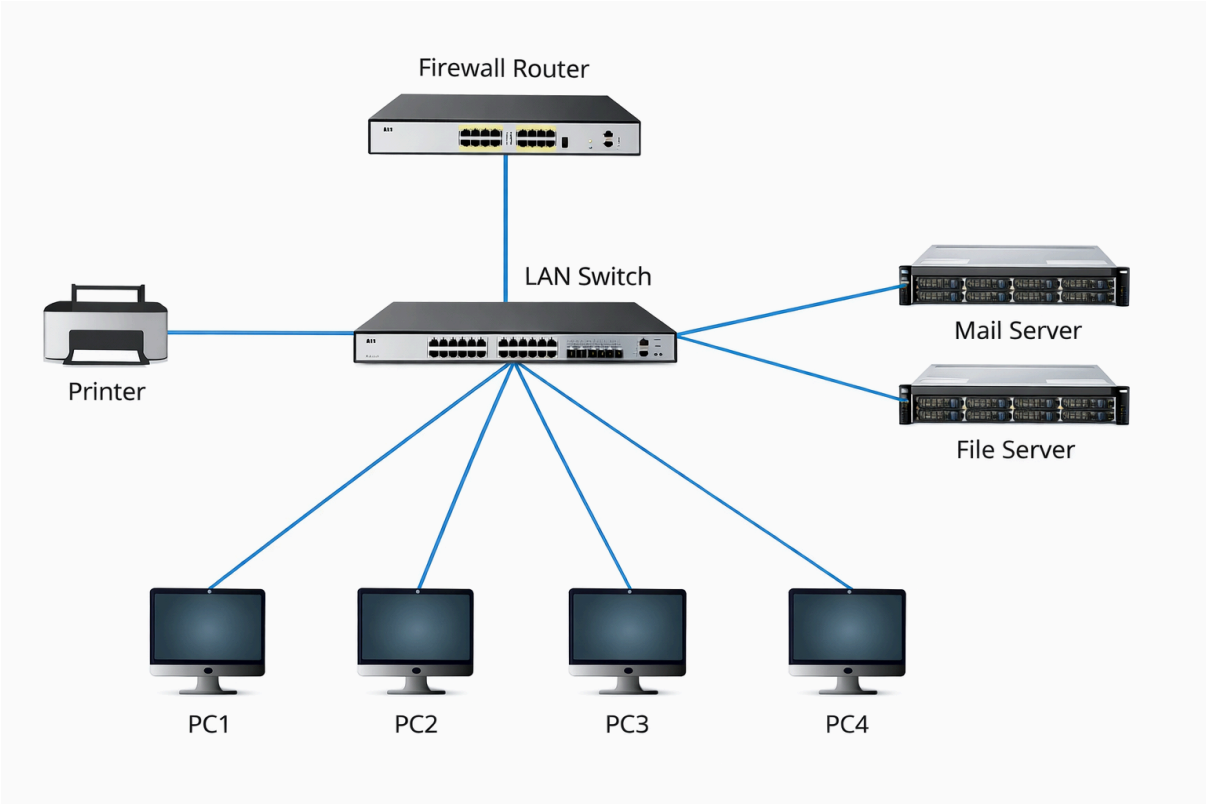
A LAN can be:

- Wireless.
- Wired.

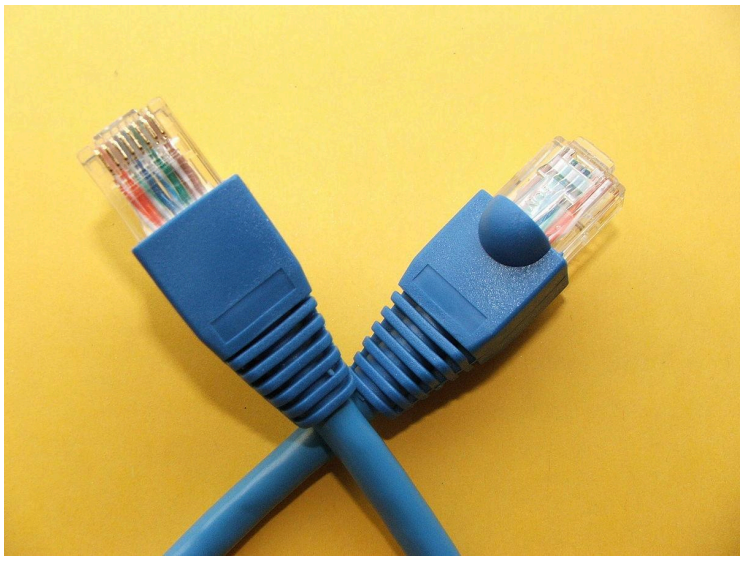
Wireless LANs
In wireless LANs (WLANs, Wireless Local Area Networks), devices communicate by radio waves with an access point or Wi-Fi router. The access point connects wireless devices to the local network (IEEE, 2024; Kurose & Ross, 2026).



Wired LANs
Wired LANs use different transmission technologies: for example, some use copper cables, while others use optical fiber (IEEE, 2022).
Wired networks generally provide greater stability, lower latency, and more predictable performance than wireless networks because the signal travels through a physical medium that is less susceptible to interference (Kurose & Ross, 2026).
LANs often use a star topology: each computer has its own connection to a switch (Tanenbaum et al., 2021).



The most common connection technology used in LANs is known as **Ethernet**, and the cable used for Ethernet connections is commonly called an **Ethernet cable** (IEEE, 2022). In everyday language, people often speak of an “Ethernet cable”, although more precisely it is a twisted-pair copper network cable, usually fitted with an RJ45 connector, used to connect Ethernet devices (IEEE, 2022).



Ethernet cable

WAN

A WAN (Wide Area Network) covers a large geographical area, often a country or a continent (Tanenbaum et al., 2021).

In simplified terms, a WAN can be divided into two main parts:

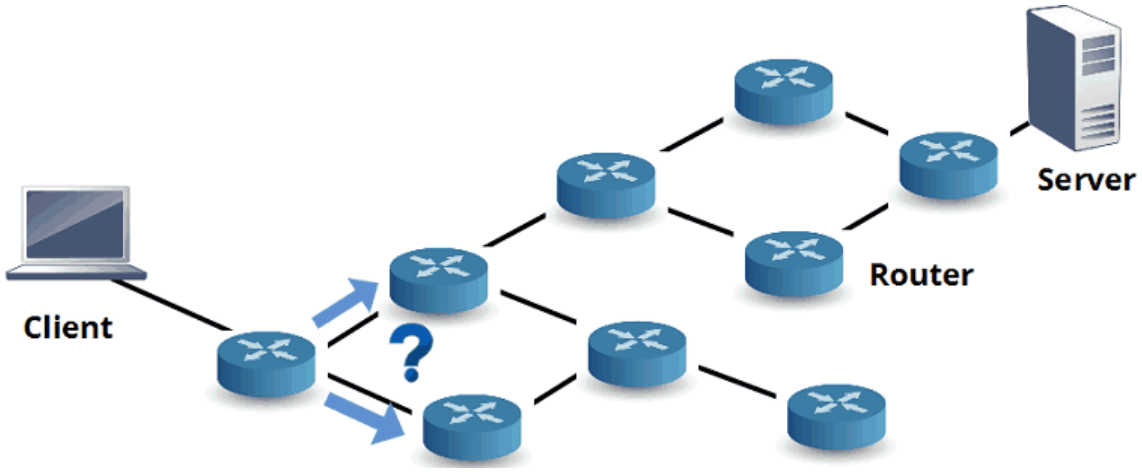
- Hosts: end devices that use the network, such as computers, smartphones, servers, or other systems.
- Communication infrastructure: the collection of transmission lines and network devices that connect the hosts. In networking texts, this communication infrastructure is often called a communication subnet (Tanenbaum et al., 2021).

The subnet, in turn, consists of two additional components:

- Transmission lines: transmission lines carry packets between machines and may be made from copper cable, optical fiber, and other media (Tanenbaum et al., 2021).
- Switching elements: switching elements are specialized routers that connect two or more transmission lines. When data arrives through an incoming line, the router must select an outgoing line through which to forward it (Tanenbaum et al., 2021).

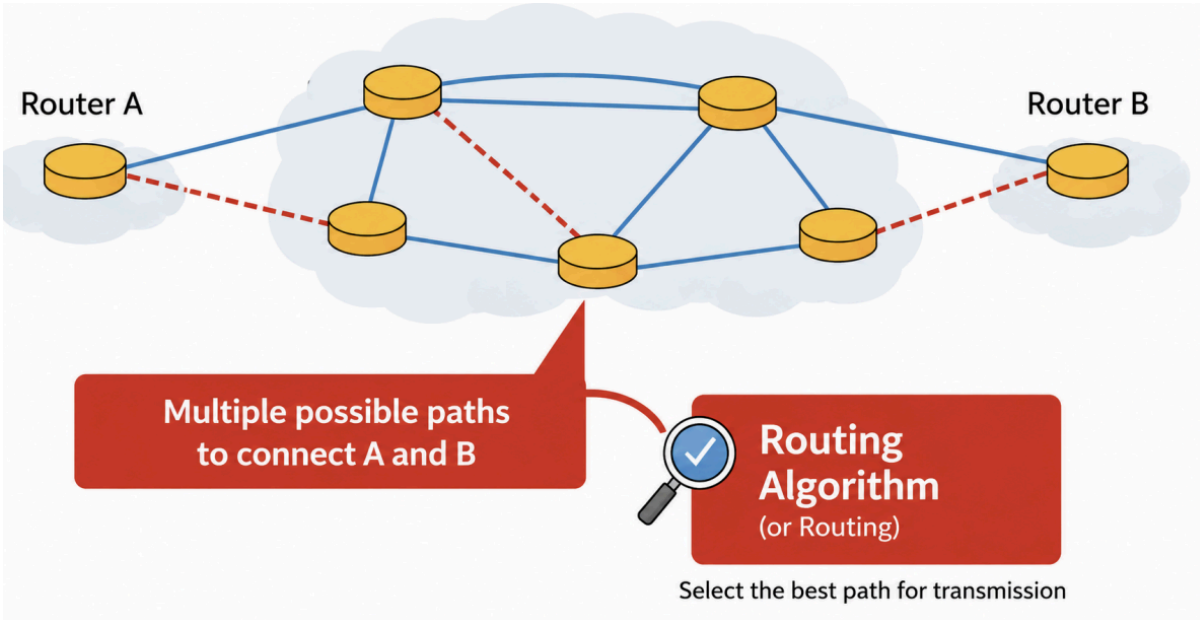
For example, in the image below:

- The hosts are the client and the server.
- The switching elements are the routers between the two hosts.
- The transmission lines are the cables connecting the routers.



In most WANs, the subnet contains many transmission lines, each of which connects a pair of routers (Tanenbaum et al., 2021).
If two routers that are not connected by the same transmission line need to communicate, they must do so indirectly by passing through other routers (Tanenbaum et al., 2021).

Because several possible paths may exist, routers use **routing algorithms** to decide which route packets should follow (Kurose & Ross, 2026; Tanenbaum et al., 2021).



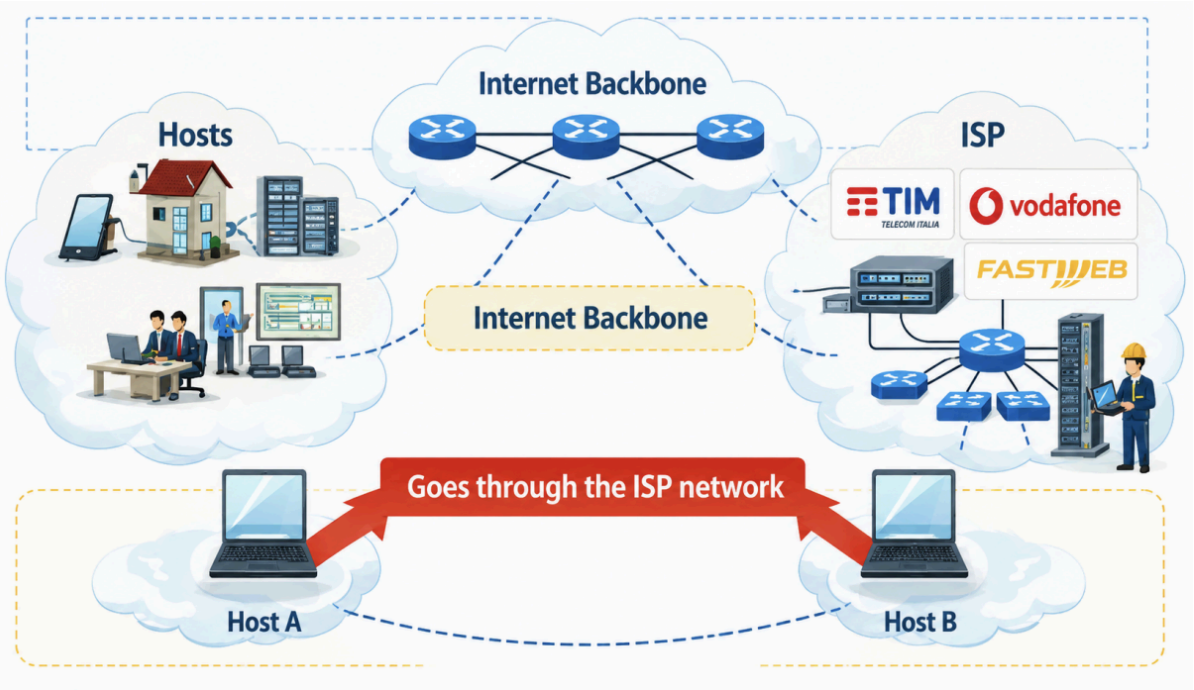
ISP

In public or commercial WANs, the hosts often belong to end users or service operators. The communication infrastructure, by contrast, is managed by network service providers that connect the various hosts requiring their services.
A network service provider connected to the Internet is called an **ISP** (Internet Service Provider), and its subnet is called an I**SP network** (Kurose & Ross, 2026).
Customers who connect to an ISP receive an Internet connection service.

Example
Examples of Italian ISPs include TIM, Vodafone, Fastweb, WindTre, and other operators that provide Internet access through fiber, mobile networks, or other technologies.(Autorità per le Garanzie nelle Comunicazioni, 2026).

To summarize:

- Subnet: the collection of routers and communication lines owned by the network operator.
- Network: the combination of the subnet and its hosts.
- Internetwork: a collection of interconnected networks.
- Internet: a particular internetwork that connects the entire world.


Internet Backbone
Hosts
ISP
TIM
TELECOM ITALIA
vodafone
FASTWEB
Internet Backbone
Goes through the ISP network
Host A
Host B

Supplementary materials

Key points

- Networks are classified by geographical coverage into **PANs**, **LANs**, and **WANs**.
- A **PAN** connects devices located very close to one another, often through USB or Bluetooth.
- **Bluetooth** is a short-range, low-power wireless technology.
- In Bluetooth communication, **pairing** associates two devices, while an active connection allows them to exchange data.
- A **LAN** connects devices within a limited area, such as a home, school, or office.
- LANs can be **wired**, often using **Ethernet**, or **wireless**, using **Wi-Fi** and access points.
- In LANs, switches forward data using **MAC addresses**.
- A **WAN** connects devices and networks over long distances through transmission lines and routers.
- Routers select the path followed by packets through **routing**.
- An **ISP** is a company that provides Internet access and manages its own network infrastructure.
- **An internetwork** is a collection of interconnected networks; **the Internet** is the world's largest internetwork.

Exercises

Classifying the Networks of a Campus

A university uses different communication systems:

- A student connects their Bluetooth headphones to their smartphone.
- The computers in a laboratory are connected to the same switch.
- Students' laptops access the building network via Wi-Fi.
- Three buildings on the same campus are connected to one another.
- The university campuses in Milan, Rome, and Palermo are connected through a wide area network.
- All university networks can access the Internet.

Analyze the situation.

- Classify each of the networks described as PAN, LAN, or WAN, and justify your choice.
- Explain why distance is a useful criterion for classifying networks, but does not represent an absolute boundary.
- Identify which communications take place within the user's personal space and which involve larger infrastructures.
- Explain why a network connecting sites located in different cities is normally considered a WAN.
- Explain why the Internet cannot simply be classified as the university's LAN.
- Identify at least one situation in the example in which different networks are interconnected.

The Headphones Will Not Connect
Giulia has bought a new pair of Bluetooth headphones. She enables Bluetooth on her smartphone, but the headphones do not appear in the list of available devices.
After several attempts, she manages to pair them and listen to music. Later, she decides to temporarily disconnect them. The next day, she turns the headphones back on and the smartphone recognizes them automatically.

A few weeks later, however, she selects the “Forget Device” option.
Reconstruct what happened.

- Explain why enabling Bluetooth on the smartphone is not sufficient to complete the first connection.
- Indicate which operation must be performed on the headphones so that they can be detected by the smartphone.
- Explain what happens during pairing.
- Explain the difference between pairing and connection.
- Explain why, after a simple disconnection, the smartphone can recognize the headphones again without repeating the pairing process.
- Explain what changes after selecting “Forget Device”.
- Explain why Bluetooth is more suitable than Wi-Fi for connecting wireless headphones to a smartphone, considering distance and energy consumption.

Designing a Laboratory Network
A school laboratory has:

- 25 desktop computers.
- 2 network printers.
- One server.
- 15 tablets.
- One switch.
- Two access points.

The desktop computers and printers can be connected by cable, while the tablets must use a wireless connection.

Conceptually design the laboratory LAN.

- Identify which devices you would connect to the switch by cable.
- Explain which technology could be used for the wired connections.
- Explain the function of the access points for the tablets.
- Explain why both wired and wireless devices can still belong to the same LAN.
- Describe the path followed by the data when a desktop computer sends a document to a printer on the same network.
- Explain the role of the MAC address in communication within the LAN.
- Compare wired and wireless connections, explaining why the former can provide more predictable performance and greater stability.
- Explain why a star topology is suitable for the wired part of the network described.

From One City to Another

A company has an office in Turin and another in Naples. Each office has its own LAN. The company wants the computers in the two offices to communicate through a wide area network.
Between the two offices, data passes through several routers and transmission lines.

Analyze the structure.

- Explain why the individual office networks can be considered LANs, while the connection between the two cities falls within the concept of a WAN.
- Identify the hosts in the situation.
- Explain what constitutes the communication infrastructure of the WAN.
- Distinguish transmission lines from switching elements within the subnet.
- A packet must pass through five routers before reaching Naples. Explain why it may be necessary to pass through intermediate machines.
- Imagine that two different paths exist to reach Naples. Explain which problem the routers must solve.
- Indicate which general mechanism is used to choose the path followed by packets.
- Explain why the user's computer does not necessarily need to know all the routers through which the packet passes.

The Telecommunications Provider's Network
Marco uses a fiber-optic connection provided by an Internet service provider. His computer belongs to his home network, but in order to reach a web server it must pass through the infrastructure of his Internet access provider.

Analyze the situation using the concepts covered in the learning material.
Explain what is meant by ISP.

- Identify who can be considered the ISP's customer in the situation described.
- Explain, in simplified terms, what an ISP network includes.
- Distinguish the concept of a subnet from that of a network.
- Explain why the provider's routers and communication lines belong to the subnet.
- Explain why Marco's computer is instead a host and not part of the provider's subnet.
- Conceptually reconstruct the path: Marco's computer → local network → ISP network → other networks → web server.
- Explain why an ISP is not the same as the Internet, even though it provides access to the Internet.

From a Network to the Internet
A large company has:

- A LAN at its Milan office.
- A LAN at its Bologna office.
- A LAN in its data center.
- Wide area connections that allow the three networks to communicate.
- A connection to an ISP that provides access to the rest of the world.

An employee states:
"We have many networks connected together, so we have created the Internet."

Evaluate the statement.

- Explain what is meant by an internetwork, or internet with a lowercase “i”.
- Determine whether the company’s interconnected networks can be considered an internetwork and justify your answer.
- Explain why this does not mean that the company has created the Internet with a capital “I”.
- Explain in what sense the Internet is defined as a network of networks.
- Identify, in the case described, which elements belong to the LANs and which connections instead require a WAN.
- Explain the role of the ISP in connecting the company network to the rest of the Internet.
- Imagine that the connection to the ISP is interrupted, but the company’s three sites can still communicate with one another. Explain which parts of the system would continue to work and which services would no longer be reachable.
- Finally, reconstruct the conceptual hierarchy covered in the learning material: host → subnet → network → internetwork → Internet.

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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 comprehensive introduction to the Internet and

modern computer networks, helping connect LANs, wireless networks, access networks, routers, ISPs, and the overall structure of the Internet. The latest edition also expands its coverage of Wi-Fi and mobile networking.

- Andrew S. Tanenbaum, Nick Feamster, and David J. Wetherall, Computer Networks, 6th ed., Pearson, 2022 — Explores network types from local to global scale and provides particularly useful coverage of LANs, broadband and wireless networks, Bluetooth, network hardware, transmission systems, and the technologies used to interconnect networks.
- Behrouz A. Forouzan, Data Communications and Networking with TCP/IP Protocol Suite, 6th ed., McGraw Hill, 2022 — Provides dedicated chapters on Local Area Networks, Wide Area Networks, connecting devices, data transfer, and packet routing, making it especially useful for deepening the distinction between LAN and WAN architectures and understanding how they are interconnected.
- William Stallings, Data and Computer Communications, 10th ed., Pearson, 2022 — Offers a broad treatment of data communications, local-area and wide-area networking, wireless communication, transmission technologies, and Internet architecture, providing a stronger telecommunications perspective on the different types and scales of networks.
- Wendell Odom, David Hucaby, and Jason Gooley, CCNA 200-301 Official Cert Guide Library, 2nd ed., Cisco Press, 2024 — Provides a practical approach to networking fundamentals, Ethernet LANs, wireless LANs, WAN architecture, routers, IP routing, and network infrastructure, making it useful for connecting the theoretical classification of networks with the way real networks are designed and managed.

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.