Network Fundamentals

Written by [Febogamedev]

A **computer network**—also called a data network or simply a network—is a group of autonomous devices connected to one another and capable of exchanging data through shared technologies (Kurose & Ross, 2026; Tanenbaum et al., 2022).

Two computers are considered connected when they are able to exchange information. The Internet is the best-known example of a computer network: it is a large global network connecting billions of hosts around the world (Kurose & Ross, 2026).

A **host** is any device connected to a network (Kurose & Ross, 2026).

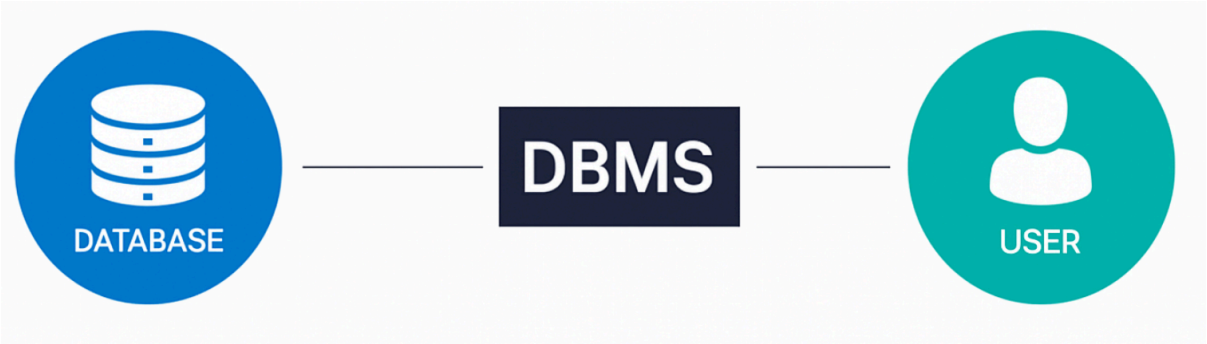
Database

A network allows multiple devices to communicate and exchange information. However, many network services do more than simply transmit data from one device to another: they must also store, organise, and retrieve it when needed.
For example, a social network must store profiles, posts, and messages; an e-commerce website must manage products, users, orders, and payments; and a school platform must store information about students, teachers, grades, absences, and communications.

Databases are used to perform these functions.

A **database** is a collection of information, or data, organised in a structured way and generally stored electronically within a computer system (Hoffer et al., 2026).

Databases are essential to the Internet because they make it possible to store, organise, and quickly retrieve enormous amounts of data reliably, such as user profiles, posts, products, payments, messages, bookings, logs, and permissions.
A database is managed by software called a **DBMS**, an acronym for **Database Management System**. A DBMS makes it possible to insert, modify, delete, search, and organise data (Hoffer et al., 2026).



Most databases are **relational databases** (Hoffer et al., 2026).
Data in relational databases is generally organised into rows and columns contained in a series of **tables** (Hoffer et al., 2026).
A table consists of:

- Fields, which are the columns.
- Records, which are the rows.

A record is a row in a table and represents a single stored item, such as a student.
A field is a column in a table and represents one of the characteristics of that item, such as first name, last name, or class.
When a new item is added to the table, a new record is inserted.
For example, adding a new student means creating a new row in the “Students” table.

Example
Below is a table containing student records, where:

- Each field is an attribute of the record.
- Each record represents one student.

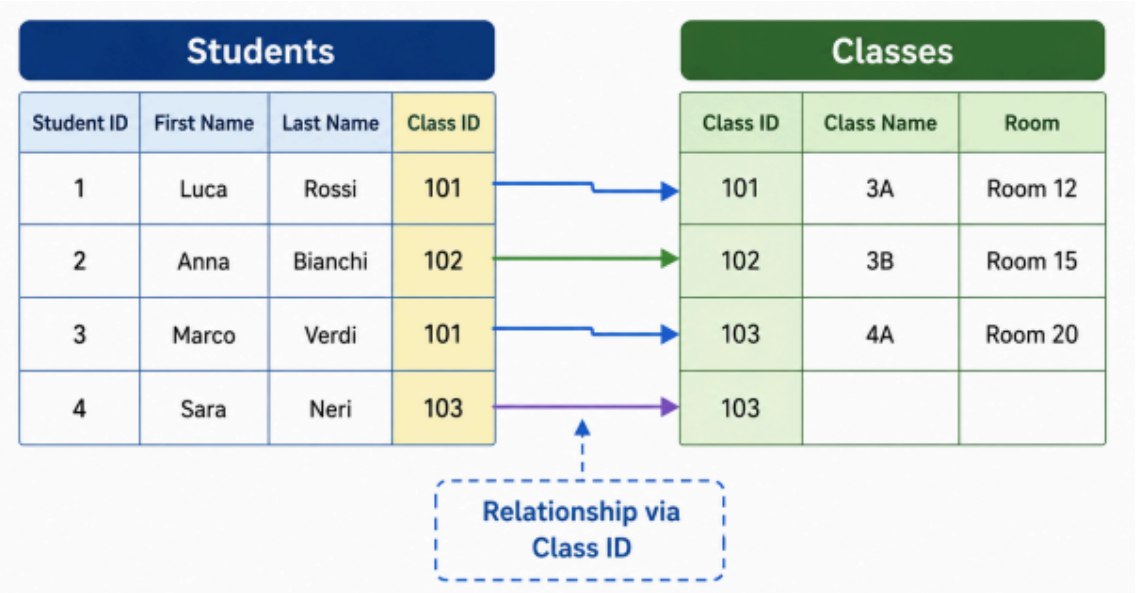
STUDENT TABLE		
First name	**Last name**	**Class**
Mario	Rossi	3
Giuseppe	Bianchi	3

Luca	Verdi	2
Mario	Russo	2
Paolo	Rossi	1

A query is a request sent to a database. It can be used to search for data, insert new data, modify existing data, or delete data.

Example
For example, a query could ask the database to display all the students in class 3A.

The main characteristic of relational databases is that tables can be connected to one another through common fields, such as an identification code or **ID** (Hoffer et al., 2026). For example, a “Students” table can be connected to a “Classes” table through the class ID. This makes it possible to organise large amounts of data, avoid unnecessary duplication, and easily retrieve information through queries.



Many relational databases use **SQL**, which stands for **Structured Query Language**, a language used to create, modify, and query tables (Hoffer et al., 2026).

Example
Imagine an application used to manage a library, in which you need to keep track of books, authors, and customers. In this case, a database could be used to organise and store all the relevant information.

Database structure

- “Books” table
  Fields: *ID*, Title, Author *ID*, Publication Year, Genre, *ISBN*, Available Quantity.
- “Authors” table
  Fields: *ID*, First Name, Last Name, Date of Birth, Nationality.
- “Customers” table
  Fields: *ID*, First Name, Last Name, Email, Telephone Number, Registration Date.
- “Loans” table
  Fields: *ID*, Book *ID*, Customer *ID*, Loan Date, Expected Return Date.

Example of use
Suppose that a new customer named Marco registers with the library and wants to borrow The Lord of the Rings by J.R.R. Tolkien. The application would use the database in the following way:

- The application checks whether The Lord of the Rings is available by examining the available quantity in the “Books” table.
- After confirming that the book is available, the application creates a new record in the “Loans” table containing information about Marco, the book, and the loan date.
- The available quantity of the book is reduced by one because one copy has been borrowed.
- If Marco returns the book by the expected return date, the application updates the record in the “Loans” table with the actual return date.
- If the application receives new books to catalogue, they are added to the “Books” table, while the corresponding authors are added to the “Authors” table.
- If a customer forgets to return a book by the expected date, the application can send a notification reminding the customer to return it.
- The application can generate reports using the information stored in the database. For example, it can display the books that are currently on loan, identify the most popular books based on the number of loans, or produce a list of the authors represented in the library.

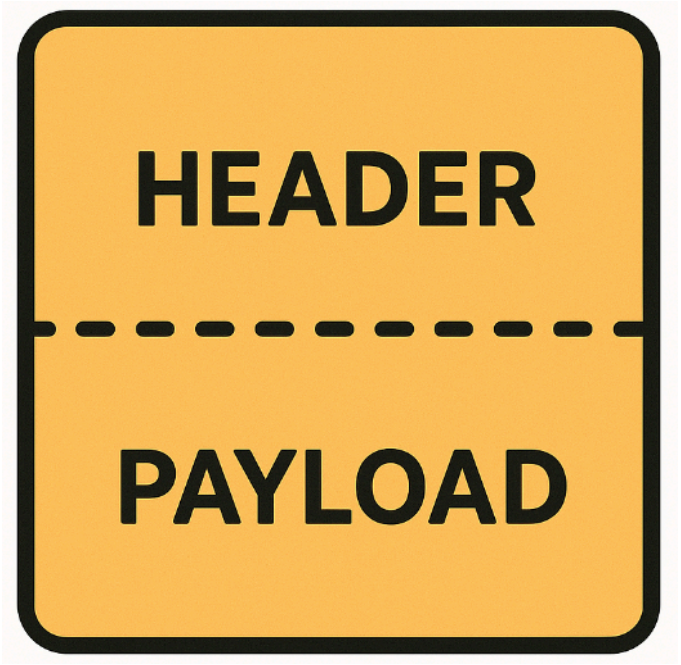
In this example, the database plays a fundamental role in organising and managing information about the library’s books, authors, and customers. It simplifies the borrowing and returning process and provides tools for analysing data about the library’s activities.

Network packet

Many network services use databases to store and retrieve information.
However, when this data needs to travel from one device to another—for example, from a server to our computer—it is not sent as a single block. Instead, it is divided into smaller units called **packets** (Kurose & Ross, 2026).
A **packet** is a small unit of data transmitted through a network. Each packet contains both technical information, which is necessary to deliver it to the correct destination, and the actual data being transmitted (Deering & Hinden, 2017; Kurose & Ross, 2026).

A packet is generally divided into two main sections:

- **Header**: contains information required for transmission, such as the sender's and recipient's addresses, and allows network devices to route the packet.
- **Payload**: contains the actual data being transmitted, such as part of the text of a message, a web page, an image, or a video (Deering & Hinden, 2017).



Supplementary materials

Key points

- **The Internet** is a global network made up of billions of connected devices, called hosts.
- **A database** stores and organizes data in electronic form.
- **A *DBMS*** is the software used to manage a database.
- In relational databases, data is organized into **tables**, made up of **records** (rows) and **fields** (columns).
- Tables can be linked through identification codes called ***IDs***.
- A **query** is a request to search, insert, modify, or delete data; many databases use the ***SQL*** language.
- Data travels across a network in the form of **packets**, which consist of a **header** and a **payload**

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Exercises

The School Network
A school has 25 computers in its computer lab, 4 network printers, a server that stores educational materials, and several tablets used by teachers. All these devices can communicate with one another through the school network.

Answer the following questions:

- Identify which devices can be considered hosts and explain why.
- Can a computer that is turned on but not connected to the network be considered a host on the school network? Explain your answer.
- A student opens a document stored on the server from their computer. Describe, in general terms, what must happen between the two devices for the student to receive the document.
- Explain why the simple fact that there are many computers in the school does not necessarily mean that a computer network exists.

Designing a Gym Database
A gym wants to create a system to manage its members. For each customer, it wants to store their first name, last name, email address, registration date, and membership type. It must also record the available classes and keep track of which classes each customer attends.

Design a possible database structure.

- Identify at least three necessary tables.
- For each table, indicate the main fields.
- Write an example record for one of the tables.
- Identify at least one field that could be used as an ID.
- Explain how you would connect the tables in order to determine, for example, which classes a specific customer is enrolled in.

- Explain what role the DBMS would play within this system.

Querying the School Database
A school uses a table called Students, consisting of the following fields:
ID | First Name | Last Name | Class | Email

The database contains 800 students.
The school administration needs to perform the following operations:
- Retrieve a list of all students in class 3A.
- Find the student with ID 427.
- Add a newly enrolled student.
- Update a student's email address.
- Delete a record that was entered by mistake.

For each operation:
- Explain what type of request should be sent to the database.
- Indicate which fields would be needed to identify the relevant records.
- Explain why using an ID can be more reliable than searching for a student only by first name and last name.
- Indicate which operations modify the data stored in the database and which only retrieve it.

You do not need to write SQL code: you only need to correctly describe what the query should do.

The Database of a Streaming Platform
A platform wants to store information about its users and the available movies.
Initially, the following single table is proposed:
Username | Email | Movie Title | Director | Year | Viewing Date

A user who watches one hundred movies therefore appears one hundred times in the table, and the information about the same movie is repeated for every user who has watched it.

Analyze the problem and propose a better solution.
- Explain what problems this data organization may cause.
- Divide the information into multiple relational tables.
- Indicate the main fields of each table.
- Introduce the IDs needed to connect the tables.
- Explain how a query could reconstruct the list of all movies watched by a specific user.
- Explain why the proposed solution reduces unnecessary repetition compared with the original table.

From the Server to Your Computer
Open an online platform and request an image stored on its server. The image must then travel across the network to your computer.

Using the concepts from the course material, describe what happens to the data during transmission.

- Explain why the image is not necessarily transmitted as a single large block of data.
- Explain what packets are.
- For a hypothetical packet carrying part of the image, indicate which information belongs to the header and which belongs to the payload.
- Explain why the destination address should not be stored only in the payload.
- Imagine that a packet correctly contains part of the image but lacks the information needed to reach its destination: explain which part of the packet contains the problem and why communication might fail.
- Finally, reconstruct the complete conceptual path: stored data → retrieval from the system → division for transmission → packets → reception on the device.

Bibliography

Deering, S., & Hinden, R. (2017). *Internet Protocol, Version 6 (IPv6) specification* (RFC 8200). RFC Editor. https://doi.org/10.17487/RFC8200

Hoffer, J. A., Topi, H., Venkataraman, R., & Bala, H. (2026). *Modern database management* (14th ed.). Pearson.

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

Tanenbaum, A. S., Feamster, N., & Wetherall, D. J. (2022). *Computer networks* (6th ed.). Pearson.

Further reading

- James F. Kurose and Keith W. Ross, Computer Networking: A Top-Down Approach, 9th ed., Pearson, 2026 — Provides an accessible introduction to computer networks and the Internet, explaining hosts, network architecture, packet switching, protocols, and the mechanisms through which data travels across interconnected networks.
- Andrew S. Tanenbaum, Nick Feamster, and David J. Wetherall, Computer Networks, 6th ed., Pearson, 2022 — Offers a broad and systematic introduction to computer networks, covering network architectures, protocols, packet transmission, network devices, and the technologies that enable communication between computers.
- Jeffrey A. Hoffer, Heikki Topi, Ramesh Venkataraman, and Hillol Bala, Modern Database Management, 14th ed., Pearson, 2026 — Provides a comprehensive introduction to database management, relational databases, data modelling, tables, relationships, database design, and SQL.
- Ramez Elmasri and Shamkant B. Navathe, Fundamentals of Database Systems, 7th ed., Pearson, 2022 — Explores the fundamental principles of database systems, including DBMS architecture, the relational model, tables, constraints, relationships, SQL, database design, and normalization.
- Abraham Silberschatz, Henry F. Korth, and S. Sudarshan, Database System Concepts, 7th ed., McGraw Hill, 2020 — Introduces database systems through an intuitive approach, with detailed coverage of the relational model, SQL, database

design, queries, data storage, and the internal mechanisms used by database management systems.

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.