

Database Management Systems

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Data Science (A.Y. 2023/2024)

Second Cycle Degree in Digital Humanities and Digital Knowledge

Alma Mater Studiorum - Università di Bologna



Summary of the previous lectures (1/2)

A **datum** is a declarative statement **subject-predicate-object** that, through the **predicate**, either **attributes** a **literal** (i.e. a value such as a string, a number, etc.) to a **subject entity** or it **relates** such a **subject entity** with **another entity**

Each entity, being used either as **subject** or **object** of a statement, is characterised by a **unique identifier**

The **same entity** can be used as **subject** or **object** in one or more data, while a literal **cannot be used** as **subject** in any datum

An attribute is intrinsically **part of** the **entity** to which it is associated – modifying the value of an attribute affect **only** the **entity** to which it refers to

A **data model** is an abstract, simplified and formal representation of some data related to a system or a real domain, and enables us to describe what a data collection is about and to check data correctness

A data model permit one to specify **classes** of entities, their **attributes** and **relations**

Summary of the previous lectures (2/2)

Depending on the structure in which data are stored (or exposed), you need to approach the queries to datasets from a different angle

- With **tabular data**, often you have to combine tables between them to obtain bigger tables which contain the query requirements and the related answer
- With **graph data**, you explore the graph starting from fixed points (i.e. known entities, values, predicates) to find a pattern that is compliant with the query

Any question about the previous lecture?

What is a database (DB)

When thinking about the world of computing, we define a **database** as a collection of data which organised, stored and accessed electronically

All data in a database are organised according to database model, that defines the particular **structure used to organise** the data (e.g. relational and graph-based)

To design a database, one has to pass through a series of steps:

1. To define the data model describing a kind of data to handle
2. To create the database structures (dependent on the particular database model in consideration) used to map the data model objects (i.e. classes, attributes and relations)
3. To upload data into the database according to the related database structures

What is a database management system (DBMS)

The creation of the database structures, the mechanism to upload new data into the database, and all the facilities for querying database data, are enabled by the **database management system** (DBMS)

A DBMS is the **software** which enables actors (users, applications, software agents) to interact with the database itself, and makes available tools to query and manage the database

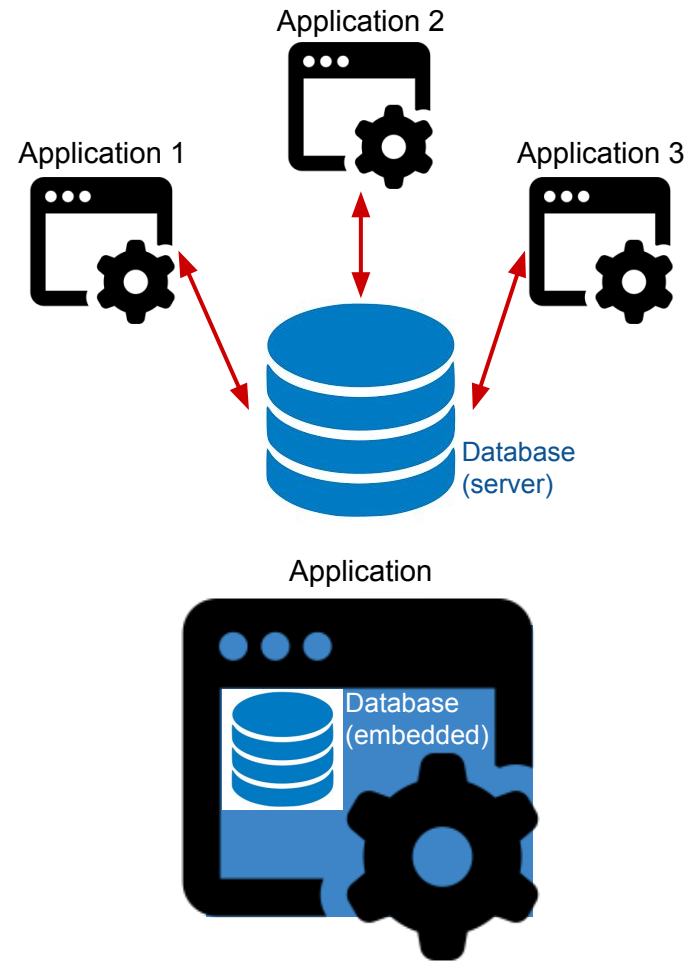
In particular, a DBMS allows one to:

- Create, modify, and remove the structures that define the organisation of the data
- Insert, modify, and delete data in/from the database
- Retrieve the data that can be returned to the user either in the form as they are stored in the database or according to new formats
- Register users, monitor and maintain performance and data integrity, and recovering corrupted information

Standalone vs embedded DBMS

Most of the DBMS available are actually developed as **standalone** applications – thus, acting as servers that store data and execute queries when requested by one or more client applications

Embedded DBMS, instead, are particular software providing tools for creating and managing databases that are directly embedded within applications – and, thus, can be considered proper libraries of such applications



DB and DBMS: some examples

DB



DBMS



Blazegraph: <https://blazegraph.com>

MySQL: <https://www.mysql.com>

OpenCitations: <http://opencitations.net>

Rfam: <https://rfam.org>

Wikibase: <https://wikiba.se>

Wikidata: <https://www.wikidata.org>

Transactions

A transaction is a unit of work performed within a DBMS against a database

Usually, it represents **any change** in a database

Every transaction is composed by **one or more operations** – e.g. think about a money transfer from a bank account to another (subtract the amount from the source bank adding it to the second bank)

Transactions are one of the main components that enables the **integrity of data**, being them executed fully or causing a rollback of the database

ACID properties

Any transaction is compliant with the following four properties:

- **A**tomicity – a transaction is irreducible and indivisible sequence of operations on a database such that either all occurs or nothing occurs
- **C**onsistency – a transaction must change a database accordingly to all defined rules and constraints the database defines
- **I**solation – it enables the correct execution of concurrent transactions, thus leaving the database in the same state that would have been obtained if the transactions were executed sequentially
- **D**urability – a transaction that has been committed will survive permanently even in the case the system crashes

Relational database

A database is relational when it is based on the relational model of data

A relational data model structures data using tables of columns and rows, where each row (or record) is identified by a unique key

Usually, each table represents one type of entity (e.g. publication or venue), while

- its rows indicates instances of that type of entity (e.g. the article with DOI “10.1162/qss_a_00023” or the venue “Quantitative Science Studies”)
- its columns representing values attributed to that instance

A table may specify that certain columns act as keys for entities

- A **primary key** is one or more columns that **uniquely identify** an entity in a table
- A **foreign key** is one or more columns that **refer to** the primary key of another table

Example of primary and foreign keys

Publication

internalId	doi	title	publicationYear	publicationVenue
Entity 1	<u>"10.1016/s1367-5931(02)00332-0"</u>	<u>"In vitro selection..."</u>	<u>2002</u>	Entity 2

Primary
key

Foreign
key

Venue

internalId	id	name
Entity 2	<u>"1367-5931"</u>	<u>"Current Opinion..."</u>

Primary
key

List of Relational DBMS

Oracle Database – <https://www.oracle.com/it/database/>

MySQL – <https://www.mysql.com>

Microsoft SQL Server – <https://www.microsoft.com/en-gb/sql-server>

PostgreSQL – <https://www.postgresql.org/>

IBM Db2 – <https://www.ibm.com/uk-en/analytics/db2>

SQLite – <https://www.sqlite.org>

MariaDB – <https://mariadb.org/>

Graph database

A database is graph-based when it uses a graph structure for representing data

Data are represented as a collection of nodes and edges, where the edges represent the relationships between the nodes (entities)

Graph databases defines data as they are defined conceptually, where

- nodes represent **entities** (publications, venues, etc.)
- edges are the mechanism to connect nodes, and can be **undirected or directed** depending on the particular approach adopted by the database
- properties are **information associated to** nodes

Resource Description Framework (RDF)

RDF is a data model based on triples subject-predicate-object called statements and used in several graph databases



List of graph databases

AllegroGraph – <https://allegrograph.com/>

Blazegraph – <https://blazegraph.com/>

Fuseki – <https://jena.apache.org/documentation/fuseki2/>

MarkLogic – <https://www.marklogic.com/>

Neo4j – <https://neo4j.com/>

Ontotext GraphDB – <https://graphdb.ontotext.com/>

OpenLink Virtuoso – <https://virtuoso.openlinksw.com/>

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