Introduction to databases

Introduction

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Information management

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Information management

- Information is recorded and exchanged in different forms

Computer systems

- In computer systems information is represented by means of data
  - the data are rough symbols which have to be interpreted and correlated to provide information
  - example
    - data: "Mario Rossi" and 424242
    - information: result of looking up a telephone number in your personal telephone directory (e.g., list of contacts)

Data characteristics

- Data are an important resource of the organization that manages them
- ICT technologies offer the possibility to store large collections of different data types and efficiently analyse these collections to extract useful knowledge
- Data are far more stable over time than the processes that manage them
  - Example
    - there have been no variations in the structure of bank applications data for decades
    - the procedures that manage the data vary from year to year

Introduction to the databases

Databases

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Database

- (General definition)
  - a database is a collection of data that represents information interesting for a computer system
- ("Technical" definition)
  - a database is a collection of data managed by a DBMS

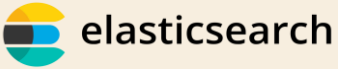
Types of databases

Relational DB

NoSQL

Object DB

Document-oriented DB



Data warehouse

Time series

Graph DB

In-memory DB

Real-time DB

... and others...

Data Base Management System - DBMS

- A DBMS (DataBase Management System) is a software system able to manage collections of data that are
  - large
  - shared
  - persistent

  ensuring their reliability and privacy

DBMS characteristics

- Far greater dimensions than the central memory available
  - data management in secondary memory
- Data sharing between applications and users: a database is an *integrated* resource, shared by several company sectors
  - reduction of data redundancy
  - reduction of data inconsistency
  - competing access control mechanism

DBMS characteristics

- Data persistence
  - lifetime not limited to execution of programmes that use them
- Data reliability in the case of hardware and software malfunction/failure
  - backup and recovery functionality
- Data privacy
  - authorization mechanisms to enable users

DBMS characteristics

- Efficiency
  - capacity to carry out operations using a set of resources (time and space) acceptable for users
    - Adequately sized computer system
- Efficacy
  - capacity to render user activities productive

DBMS or file system?

- "Simplified" approach to data: data stored in the persistent mode in the mass/secondary memory inside the file
  - it is possible to memorize and look for data
  - simple access mechanisms (sequential reading)
  - simple sharing mechanisms (read only sharing with writing options blocked)
- DBMS extends the functionalities of the file systems, providing more integrated services

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Data model

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Data model

- A data model is a set of concepts utilized for organizing data of interest and describing its structure in a way that is understood by a computer
  - elementary data types (integer, character...)
  - structuring mechanism for defining more complex structures (record builder, array,...)

Types of data models

- Relational data model
  - Most widespread data model
  - Data organized into sets of homogeneous (fixed structure) records and represented as tables
- Before the relational model, other models closer to the physical (not very abstract) structures of storing were used
  - hierarchical model, network model
- Since the relational model
  - Object model, XML, NOSQL databases, …

Relational model

Courses

Code	Name	TeacherID
M2170	Information systems	D101
M4880	Computer Networks	D102
F0410	Databases	D321

Teacher

ID	Name	Department	Phone#
D101	Green	Computer Engeneering	123456
D102	White	Telecommunications	636363
D321	Black	Computer Engeneering	414243

Schema and instances

- Defined in the database are
  - the *schema*, which describes the structure of the data. The schema
    - is practically unvarying over time
    - is represented by the heading of each table (table name and column names)
- Example
  - schema of the database

Courses	Code	Name	TeacherID	
Teacher	ID	Name	Department	Phone#

Schema and instances

- Defined in a database are
  - the *instance*, composed of the content of each table, i.e. of the data effective values which are
    - variable over time, also very rapidly
    - represented by the rows in the tables
- Example
  - instance of the Teacher table

D101	Green	Computer Engeneering	123456
D102	White	Telecommunications	636363
D321	Black	Computer Engeneering	414243

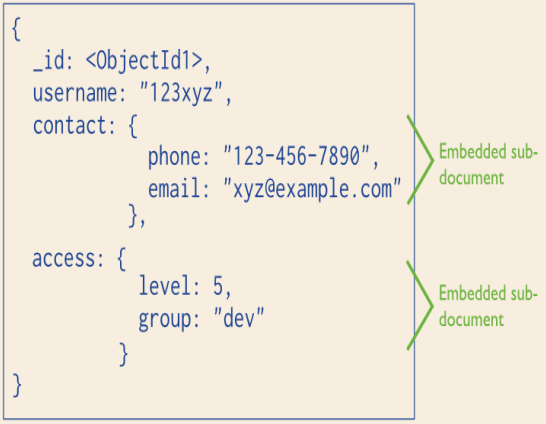
Example of other data models: NOSQL database

- A database is a set of collections
- Each collection contains a set of documents
- Each document is described by a list of key-value fields and each field can hold any data type
- Documents from the same collection can be heterogeneous
- Since the data representation is schema-less it not required to define the schema of the documents a-priori and objects of the same collections can be characterized by different fields

Relational database	NOSQL database
Table	Collection
Row	Document
Column	Field

Example of Document Data

- Relations among documents are inefficient, and leads to de-normalization
  - Object(ID) reference, with **no native join**



Model types

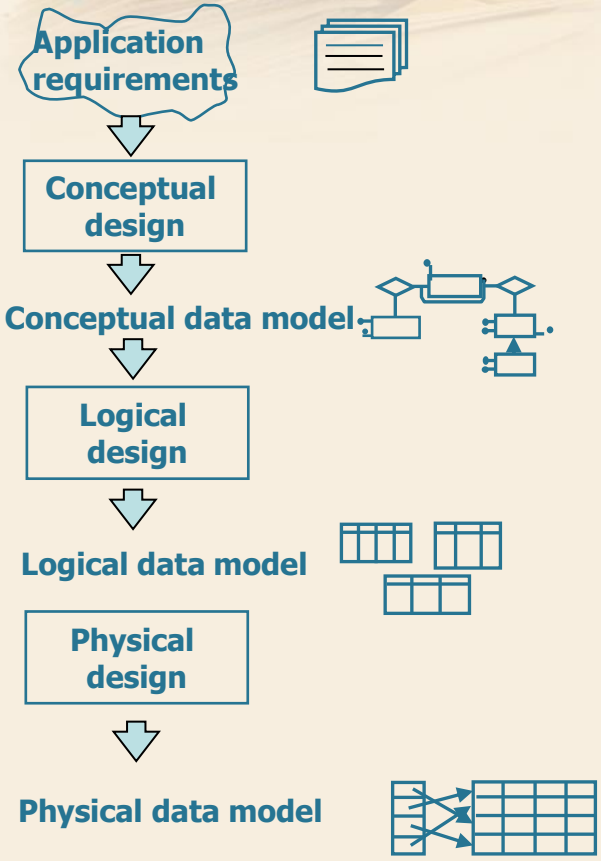
- *Conceptual model*
  - It is possible to represent data independently from the logical
    - describes real world concepts
    - used in the designing phase
  - example: entity-relationship model
- *Logical model*
  - Describes the data structure in the DBMS
    - used by the programmes accessing the data
    - independent from the physical structures
  - Example: relational model

Database design flow

To represent the informal requirements of an application in terms of a conceptual schema that refers to a conceptual data model

Translation of the conceptual schema defined in the preceding phase, into the logical schema of the database that refers to a logical data model.

The logical schema is completed with the details of the physical implementation (file organization and indexes) on a given DBMS. The product is called the physical schema and refers to a physical data model.



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Data access

Data access languages

- User-friendly interfaces that enable specific queries without using a textual language
- Interactive languages (SQL)
- Commands similar to interactive commands introduced into traditional programming languages (C, C++, COBOL, Java, …), so-called host languages
- Commands similar to interactive commands introduced into ad hoc development languages, often with specific functionalities (generation of graphics, complex prints, screens)

Data access languages

- Languages are divided into two categories
  - *Data Definition Languages* (DDL) used to define the logical, external and physical schemas, and access authorizations
  - *Data Manipulation Languages* (DML) used for querying and updating database instances

Users

- Database administrator: in charge of (centralized) control and management of the database
  - guarantees sufficient performance
  - ensures system reliability
  - manages authorizations and access to data

Users

- Designers and programmers: they define and realize
  - the structure of the database
  - the programmes accessing the database
- Users: utilize the database for their activities
  - end users: they use transactions, i.e. programmes that carry out predefined activities
  - casual users: they formulate queries (or updates) which are not predefined by the interactive access languages of the database

Transactions

- Programmes that carry out frequent predefined activities
- Examples
  - flight bookings
  - bank transfers
- Generally realized by introducing SQL into a host language

Introduction to the databases

Advantages and disadvantages of DBMS

DBMS advantages

- Data as a common resource of the whole organization
  - reduction of redundancies and inconsistencies
- Unified and precise data model of facts of interest to the organization
- Possible centralized control of data
  - standardization, economies of scale
- Data independence

DBMS disadvantages

- These are expensive, complex products that require
  - direct investment
    - purchase of the product
  - indirect investments
    - purchase of the necessary hardware and software resources
    - conversion of the applications
    - training of personnel
- They provide a set of services in an integrated form
  - it is not possible to separate out unused services that cause a reduction in performance

Introduction to databases

Business intelligence

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Business Intelligence

- BI provides support to strategic decision support in companies
- Objective: transforming company data into actionable information
  - at different detail levels
  - for analysis applications
- Users may have heterogeneous needs
- BI requires an appropriate hardware and software infrastructure
- Mined information can be visualized using informative dashboards