Data Management and Databases

Welcome to the Data Management and Databases course!

Introduction to databases

- The learning objectives for this week are:
    - Knowing what kind of topics are covered during the course
    - Knowing the course schedule and the purpose of the weekly teaching sessions
    - Knowing how the course is assessed
    - Knowing the objective of *data management*
    - Knowing the meaning of the term *database* and *database management system* (DBMS)
    - Knowing wat kind of functions a full-scale DBMS should provide
    - Knowing and advantages of the *database approach* over the *file-based approach* in data management

About the course

- During the course, we will learn among other things:
    - The key concepts and terminology of data management and databases
    - Design and document the database's structure based on the requirements
    - Retrieve and manipulate the database's data with SQL
- Each week there are two different teaching sessions:
    - Lectures where we go through the theory of the weekly topics
    - Laboratory sessions where we apply what we've learned by working on exercises together
- The teaching session schedule can be found on the course's Moodle page
- There are mandatory weekly exercises that need to be submitted in Moodle before the next week's lecture

Assesment

- ⚠️ To confirm the course participation the following need to be submitted before the second week's session:
  - The first part of your learning diary
  - The first week's assignments (orientation exercise and intro assignment)
- The course assesment is based on the combined points from two exams:
  - The first exam, half way through the course, will cover SQL operations
  - The second exam, at the end of the course, will cover rest of the course topics
- The exercise submission have can have an impact on the final grade in borderline situtations
- More details about the exam schedule and practicalities can be found in Moodle

Database

> "*A representation of facts or ideas in a formalized manner capable of being communicated or manipulated by some process*"
>
> — Definition for the word "Data" in Oxford Languages

> "*A permanent structure for housing something*"
>
> — Definition for the word "Base" in Oxford Languages

- In a digital world we are constantly accessing and manipulating stored information:
  - When we open our favorite messaging app, we can see the previously sent messages and we can send new messages
  - When we pay a bill and transfer money from one bank account to another
- These kinds of shared collections of logically related information are *databases*

Definition of database

- In general, database can be defined as...
  - a *shared collection* of
  - *logically related persistent data* and
  - a *description of this data*,
  - designed to meet the *information needs*

Definition of database

- "shared collection": database is accessible to specific applications, users, and organizations
- "logically related data": the different pieces of information has logical relations, e.g. messages in a messaging app are related to the sender and the receiver users
- "persistent data": data is in permanent storage and doesn't unexpectantly vanish
- "description of this data": on top of the actual data such as the user's name, the database contains *metadata* like table and column names
- "information needs": the kind of information stored in the database is use-case specific
    - For example, a simple messaging app needs to store information about users and messages

Data management

- *Data management* is the development, maintenance and coordination of *database systems*
- A database system consists of five major components: *hardware*, *software*, *data* (the database), *procedures* and *users*
- Procedures refer to the policies, conventions, instructions, and rules that govern the design and use of the database

The objective of data management

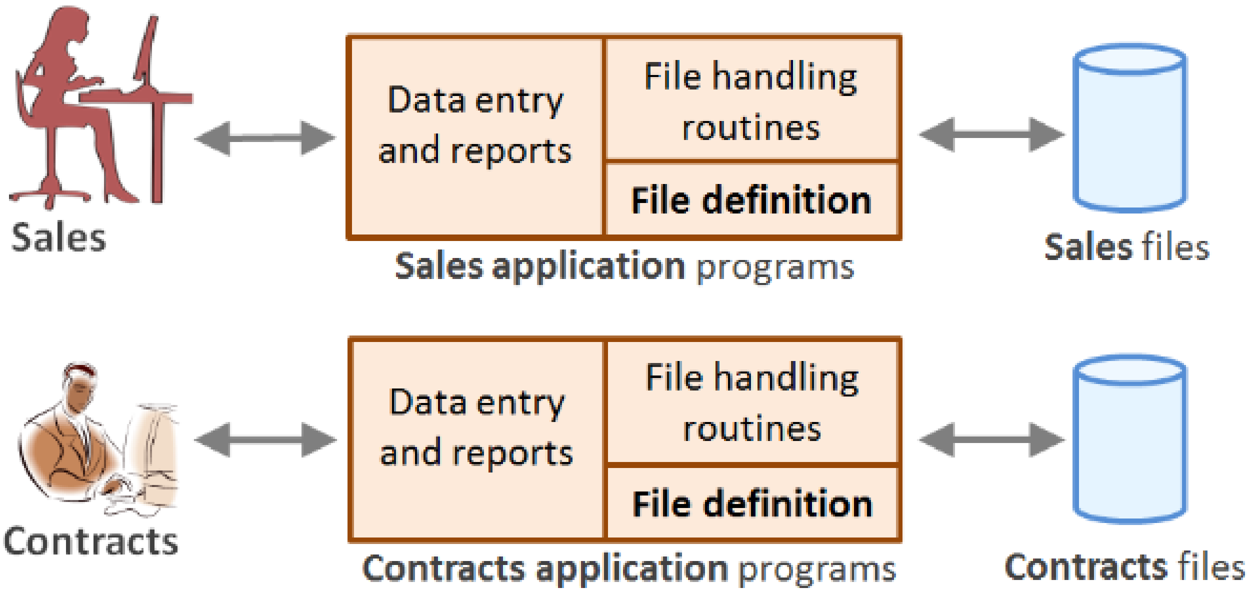
- The objective of data management is to design, implement, coordinate, and maintain database systems in such a way that all the required data is:
    - Valid and consistent
    - Up to date
    - Available in the required format
    - Available when needed
    - Fetrievable fast enough
    - Safe from different types of technical failures and accidents
    - Protected from unauthorized access and other types of misuse

Data management example

- Let's consider the following information needs for a database:
    - A real estate company is renting properties
    - Each property has a property owner and a lease if the property is rented
    - Each lease has a client who is renting the property from the owner
    - The company has a sales team responsible for finding clients for the available properties and a contracts team responsible for managing the leases

File-based approach in data management

- Data for sales and contracts teams is in *separate files*
- Each team uses a separate application that defines and manages data in application-specific files
- Each file has a specific format
- Applications that use these files depend on knowledge about that format



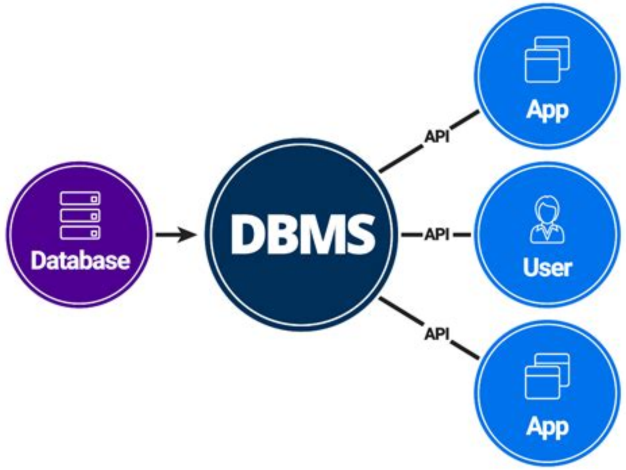
- In the filesystem, there are the following sales files:
  - PrivateOwner (ownerNo, fName, lName, address, telNo)
  - PropetyForRent (propertyNo, street, city, postcode, rooms, rent, ownerNo)
  - Client (clientNo, fName, lName, address, telNo, prefType, maxRent)
- And the following contracts files:
  - Lease (leaseNo, propertyNo, clientNo, paymentMethod, deposit, paid,
  - rentStart, rentFinish, duration)
  - PropetyForRent (propertyNo, street, city, postcode, rent)
  - Client (clientNo, fName, lName, address, telNo)

Problems of file-based approach

- Data dependence
  - Code is tightly coupled with the file structure: if it is modified, all programs that use the file have to be changed accordingly
- Duplication of data
  - Storing the same information in multiple files (e.g. the Client files in both sales and contacts teams) will lead to inconsistency
- Difficulty in accessing data
  - New requirement needs a new program or changes in an existing program
- No provision for security and shared access to the data
  - No service for providing user access to some, but not all, data
- Lack of coordination and standardisation
  - No centralised control of enterprise data

Database Management System (DBMS)

- Problems of the file-based approach can be avoided by delegating data related operations to a *separate software*
- *Database Management System* (DBMS) is the software that:
    - Controls all access to the database
    - Allows users to define the database, usually through a *Data Definition Language* (DDL)
    - Allows users to insert, update, delete, and retrieve data from the database, usually through a *Data Manipulation Language* (DML)



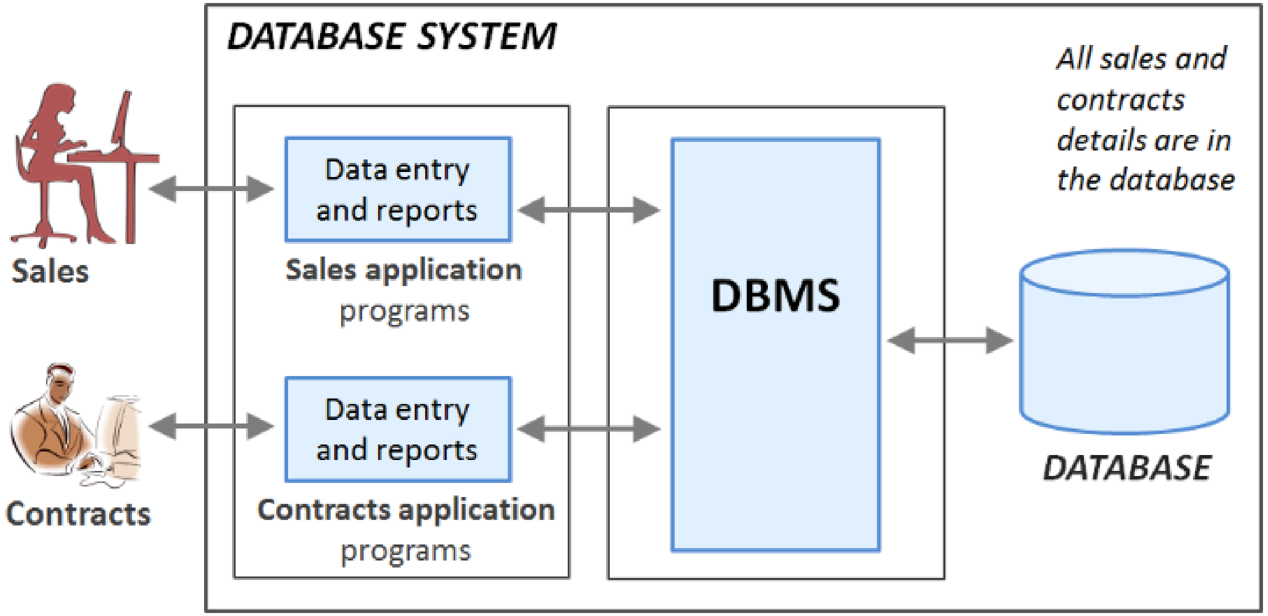
Data manipulation comparison

```
# Fetching data from a DBMS:
connection = psycopg2.connect(
  # ...
)
cursor = connection.cursor()
cursor.execute("SELECT clientNo, fName, lName, address, telNo FROM Client")
clients = cursor.fetchall()

# Fetching data from a file:
file = open("clients.csv", "r")
clients = []
for line in file:
  columns = line.split(",")
  clients.append((columns[0], columns[1], columns[2], columns[3], columns[4]))
```

Database approach in data management

- Data for both sales and contracts team is in the *same database*
- Each team uses a separate application that communicates with the same DBMS using a data manipulation language
- The DBMS retrieves and manipulates data in the database on behalf of the application


DATABASE SYSTEM
All sales and contracts details are in the database
Sales
Data entry and reports
Sales application programs
Contracts
Data entry and reports
Contracts application programs
DBMS
DATABASE

In the database, the structure of sales and contracts details is the following:

- *PrivateOwner* (ownerNo, fName, lName, address, telNo)
- *PropetyForRent* (propertyNo, street, city, postcode, rooms, rent, ownerNo)
- *Client* (clientNo, fName, lName, address, telNo, prefType, maxRent)
- *Lease* (leaseNo, propertyNo, clientNo, paymentMethod, deposit, paid, rentStart, rentFinish)

Advantages of database approach

- Program-data independence
  - Improved data accessibility
- Effective access to data
  - Standard database language with both programmatic and interactive interfaces
- Data integrity
  - Integrity can be maintained with the support of user-defined integrity constraints
- Data security
  - Security restrictions can be applied on detailed level
- Coordination and standardisation
  - Centralised data administration

Functions of a DBMS

- The most fundamental function of DBMS is *retrieving and manipulating data in the database*
- This function should be provided in such a way that the physical level storage structures are completely hidden from the user
  - This offers a great amount of flexibility: the storage structures can change without the need to touch the application's code
- Other important functions of a DBMS are:
  - Integrity Services
  - Transaction Support
  - Concurrency Control Services
  - Recovery Services
  - Authorization Services

Database Management System (DBMS)

- Nowadays, the *relational database management system* (RDBMS) is the de facto standard
- *SQL* is the formal and de facto database language standard for RDBMSs
- SQL has both DDL and DML features
- There are multiple RDBMS products, such as *MySQL* and *PostgreSQL*

Summary

- *Database* is a shared collection of logically related persistent data
- Database is designed to meet specific information needs
- *Data management* is the development, maintenance and coordination of *database systems*
- *Database management system* (DBMS) is a software that allows users to insert, update, delete, and retrieve data from the database
- The most fundamental function of DBMS is *retrieving and manipulating data in the database*