Introduction to Databases
(INFR10080)

Dr Paolo Guagliardo

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Data

The **most important asset** of any enterprise

Must be effectively, efficiently and reliably

- collected and stored
- maintained and updated
- processed and analysed

to be turned into meaningful information

$\Longrightarrow$ Enable and **support decision making**

What is a database?

A collection of data items related to a specific enterprise, which is structured and organized so as to be more easily accessed, managed, and updated

Data**b**ase **M**anagement **S**ystem (DBMS)

- software package for creating and managing databases
- mediates interaction between end-users (incl. applications) and the database
- ensures that data is consistently organized and remains easily accessible

Why use a DBMS?

- Uniform data administration
- Efficient access to resources
- Data independence
- Reduced application development time
- Data integrity and security
- Concurrent access
- Recovery from crashes

Different kinds of data(bases)

- A **data model** is a collection of concepts for describing data
- A **schema** is a description of a particular collection of data, using a given data model

Relational databases ⟸ main focus of this course

Data organised in tables (relations) with typed attributes

Document stores

Text documents structured using tags (or other markers)

Graph databases

Data organised in graph structures with nodes and edges

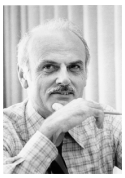
Key-value stores

Data organised in associative arrays (a.k.a. dictionaries or maps)

The relational model

First proposed by Edgar F. Codd in 1970

Simple idea: Organise data in **tables** (relations)



Schema

- Set of **table names**
- List of distinct (typed) **column names** for each table
- **Constraints** within a table or between tables

Instance

- Actual data (that is, the rows of the tables)
- Must satisfy typing and constraints

Example: relational database

Customer

CustID	Name	City	Address
cust1	Renton	Edinburgh	2 Wellington Pl
cust2	Watson	London	221B Baker St
cust3	Holmes	London	221B Baker St

Account

Number	Branch	CustID	Balance
243576	Edinburgh	cust1	-120.00
250018	London	cust3	5621.73
745622	Manchester	cust2	1503.82

Query languages

Used to ask questions (queries) to a database

Procedural

Specify a **sequence of steps** to obtain the expected result

Declarative

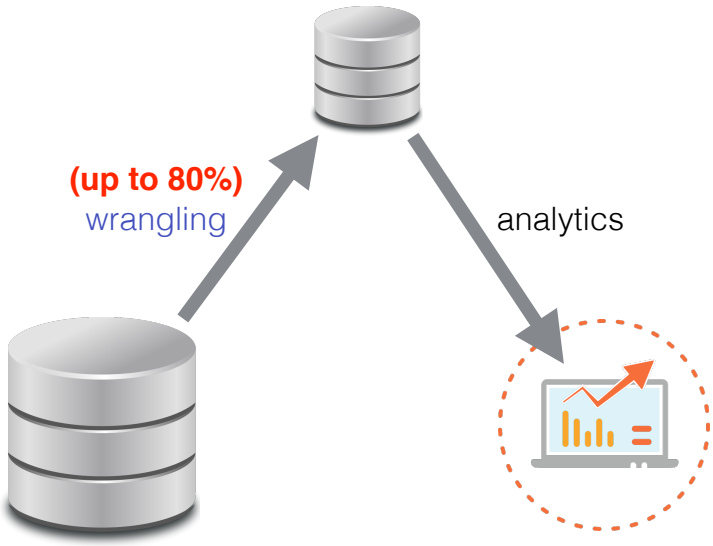
Specify **what** you want not **how** to get it

- Queries are typically asked in a declarative way
- DBMSs figure out internally how to translate a query into procedures that are suitable for getting the results

SQL

- **S**tructured **Q**uery **L**anguage
- Declarative language for querying relational databases
- Implemented in all major (free and commercial) RDBMSs
- First standardized in 1986 (ANSI) and 1987 (ISO); several revisions afterwards (latest Dec 2016)
- Multi-billion-dollar business
- Most common tool used by data scientists

Accessing data is at the core of data analysis



Studying SQL is not enough

DBMSs encompass many areas of Computer Science:

Operating systems, Algorithms and data structures,
Formal logic, (Programming) languages, Multimedia, ...

Goals of this course

- **Create and modify a relational database**
  using standard software tools available on the market
- Compare strengths and weaknesses of different **database designs**
- Process and analyse data by means of complex SQL statements
- Formulate and manipulate queries
  in both **declarative and procedural database languages**
- Reason about the correctness and consistency
  of **concurrent database interactions** among multiple users
- Understand the **how queries are optimized and executed**
  in relation with **how data is stored and organised**

Syllabus

Core topics

- Query languages: **SQL**, relational algebra and calculus
- Database design: constraints and normal forms
- Scheduling and concurrency control: serializability, locking
- Database access from applications: embedded/dynamic SQL
- Query evaluation and optimisation: join strategies, query plans

Advanced topics (if time allows)

- Deductive databases: Datalog and recursive queries
- Incomplete data: missing values and certain answers
- Storage and indexing: B+ trees, static hashing

Prerequisites

- Some background in discrete mathematics
- Familiarity with **predicate logic** is a plus
  (but this will be introduced during the course)
- Familiarity with **Unix command line** is a plus
  (knowing the basics will make your life easier)
- No specific programming requirements
  (we will see some very simple Python programs)

The course is overall self-contained

Textbook (1)

Main text

Ramakrishnan, Gehrke:
Database Management Systems
McGraw-Hill, 3rd edition

Not mandatory

Materials from lectures and tutorials are enough

Availability

- **Main Library** (George Square): **3 copies** (3 hours loan)
- **Murray Library** (King's Buildings): **6 copies** (12 weeks loan)
- **Blackwell's** (Nicholson St): **10% student discount**

Textbook (2)

Further reading — *Abiteboul, Vianu, Hull*
Foundations of Databases
Addison-Wesley, 1995

- Mostly theoretical topics
- Out of print but freely available (for **personal use only**)
  http://webdam.inria.fr/Alice/

Course website(s)

All course materials and announcements are on **Learn**

Class discussions will take place on **Piazza**:

https://piazza.com/ed.ac.uk/fall2020/infr10080/home

No need to signup for the class

I will enrol you using your **uun email address**

Rather than emailing questions, post them on Piazza

- You can post **privately** to instructors (tutors and me)
- You can post **anonymously** to classmates

Tutorials

- They will start in week 3 or week 4
- Discuss **formative** exercises assigned throughout the course
- Tutorial sheets will be made available one week in advance
- Marks for submitting **attempts** at solving the exercises
- Solutions to tutorial exercises will be posted on Learn

Coursework

Accounts for **60%** of the final mark

Participation in tutorials **10%**

- Submitting attempts at solving assigned exercises (independently of correctness) **Max marks: 70/100**
- Actively contributing to Piazza discussions (for **extra marks**)

SQL assignment **25%**

- Requires writing SQL queries to a given specification
- Marked automatically (details later on)
- Possibly there will be an optional dry-run

Online test **25%**

- Taken from home via Learn
- Multiple-choice questions, plus 1 to 3 open-ended ones
- Open-ended questions marked only if the rest are correct

Exam

Accounts for **40%** of the final mark

Diets

- December 2020: open to all students

Structure

- See past exam papers for sample questions: https://exampapers.ed.ac.uk/

Software: PostgreSQL

- Open-source, commercial-level relational DBMS
- Installed on all **DICE machines**
- Available for Windows, Mac, Linux (and more)
- Very simple to compile and install on your laptop
- Each enrolled student has their own **personal database** (hosted on the university's central PostgreSQL server)
- Instructions will be posted on Piazza
- You will use it to write **SQL queries** for the coursework

Other stuff

Lecture recording

- Lectures will be recorded
- Links to the recordings will be **posted on Learn**

Lecture slides

- Handouts for all topics are available on Learn
- Keep an eye out for the **latest version**

  before class: version number next to view/download links

  after class: an announcement will also be sent out

Office hours

- **Weekly meetings** (interest must be registered in advance)
- I am usually available for quick questions after class
  (but do not forget to **use Piazza** where possible)