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MODERN DATABASES AND NOSQL

Prof. Dr.-Ing. Michael Wiehl

Infos on the module

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- 5 ECTS
- 4 SWS (2 + 2)

- Work load
  - Contact time: 60 h
  - Self study: 90 h = approx 5-6h per week

Evaluation of learning success

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- Project for design and implementation of a database management system of a selected application
- Result: Project report (10 pages)

Moodle course

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- Slides of the lectures
- References to online learning material
- Examples
- Videos

Learnings

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- know the **basics of relational database systems** and can understand and compare them with other forms of data organization
- name examples of the use of relational database systems and list the possibilities of linking databases to application programs
- know the syntax of a common access language and can apply it
- learn about **distributed data models** as well as platforms and frameworks for distributed data, such as NoSQL databases

Learnings

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- be able to independently design, create, and query databases
- Students refine their knowledge of modern databases, including distributed data models
- By designing and building complex infrastructures, students deepen their ability to abstract
- Students learn a confident approach to modern database applications and infrastructures.

- Students will be able to model, discuss, and present modern databases to a larger audience in small groups
- Through independent learning, students will acquire time management skills.

Course structure

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Prof. Wiehl – Classic DBs / Relational Databases

- Design of databases systems
- Modelling
- Designing a database
- Normalisation
- Quering SQL Databases

Prof. Pirkl – Modern Databases / NoSQL

- Scalability
- Key value stores
- Comparison of DBs
- Time series & Elastic search
- Distributed Systems

Literature

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- „Advanced Data Management“, Lena Wiese, De Gruyter Graduate, 2015
  - Chapter 1: Entity Relationship Model, UML
  - Chapter 2: Relational DBMS, Mapping ER, Normalization, Transactions

- „Getting Started with SQL and Databases“, Mark Simon, apress, 2023
  - Querying and Working with SQL databases, joining tables, sorting

Your knowledge? – Stand up and sit down

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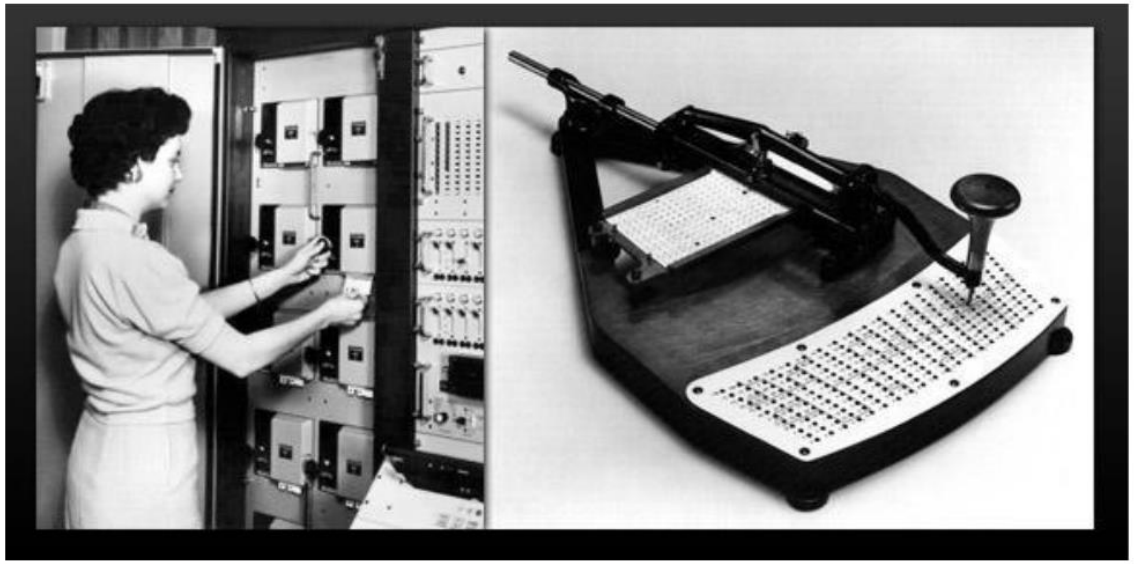
- You know what a database?
- Working with databases?
- You queried a database?
- You have built a new database by your own?

History of databases

- 1950s and early 1960s:
  - Data processing using magnetic tapes for storage
  - Tapes provided only sequential access
  - Punched cards for input



Punched card reader (L) and writer ® | Image from A Brief History of Communication Technology.

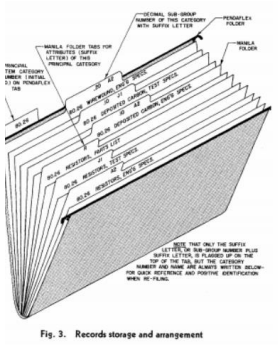


Fig. 3. Records storage and arrangement

- Data in a file system

Make your own:

http://www.kloth.net/services/cardpunch.php

History of databases

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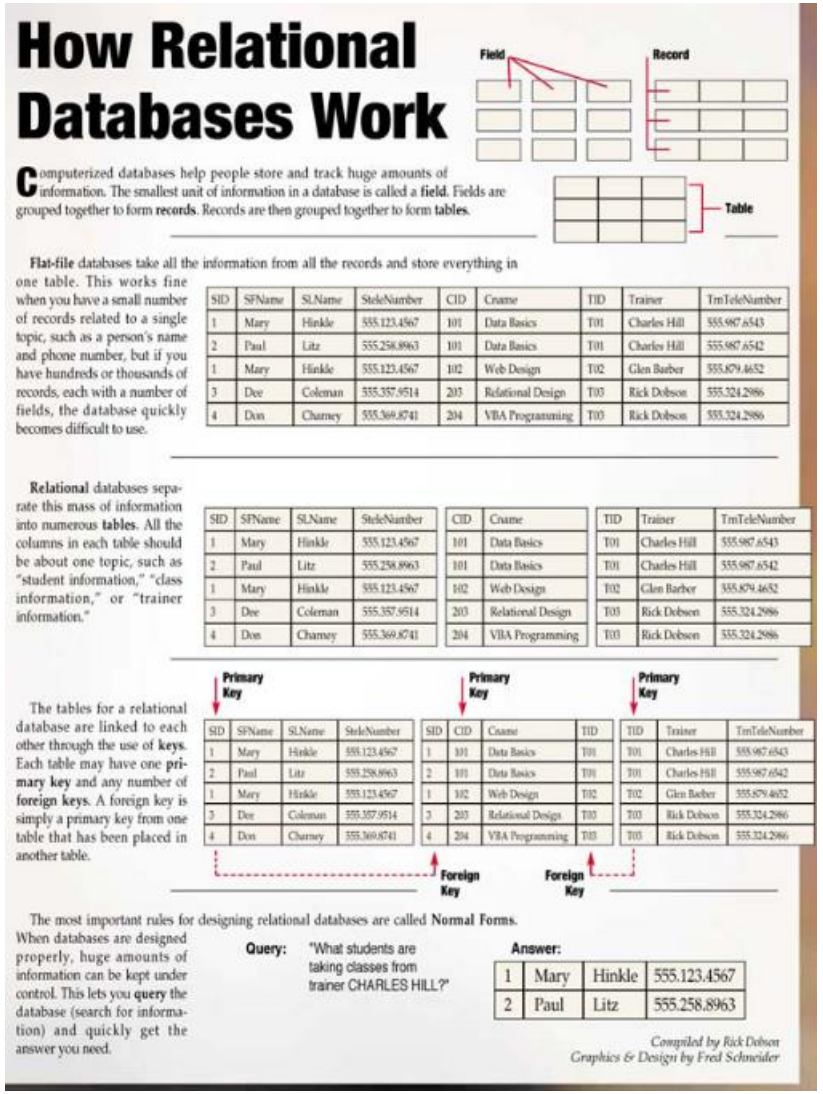
- Late 1960s and 1970s:
  - Hard disks allowed direct access to data
  - Network and hierarchical data models in widespread use
  - Ted Codd defines the relational data model
    - IBM Research begins System R prototype
    - UC Berkeley (Michael Stonebraker) begins Ingres prototype
    - Oracle releases first commercial relational database
  - High-performance (for the era) transaction processing



How Relational Databases Work

Computerized databases help people store and track huge amounts of information. The smallest unit of information in a database is called a **field**. Fields are grouped together to form **records**. Records are then grouped together to form **tables**.

Flat-file databases take all the information from all the records and store everything in one table. This works fine when you have a small number of records related to a single topic, such as a person's name and phone number, but if you have hundreds or thousands of records, each with a number of fields, the database quickly becomes difficult to use.

SID	SFName	SLName	SteleNumber	CID	Cname	TID	Trainer	TrnTeleNumber
1	Mary	Hinkle	555.123.4567	101	Data Basics	T01	Charles Hill	555.987.6543
2	Paul	Litz	555.258.8963	101	Data Basics	T01	Charles Hill	555.987.6542
1	Mary	Hinkle	555.123.4567	102	Web Design	T02	Glen Barber	555.879.4652
3	Dee	Coleman	555.357.9514	203	Relational Design	T03	Rick Dobson	555.324.2986
4	Don	Charney	555.369.8741	204	VBA Programming	T03	Rick Dobson	555.324.2986

Relational databases separate this mass of information into numerous **tables**. All the columns in each table should be about one topic, such as "student information," "class information," or "trainer information."

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The tables for a relational database are linked to each other through the use of **keys**. Each table may have one **primary key** and any number of **foreign keys**. A foreign key is simply a primary key from one table that has been placed in another table.

Primary Key — Primary Key — Primary Key

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1	Mary	Hinkle	555.123.4567
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Foreign Key — Foreign Key

The most important rules for designing relational databases are called **Normal Forms**. When databases are designed properly, huge amounts of information can be kept under control. This lets you **query** the database (search for information) and quickly get the answer you need.

Query: "What students are taking classes from trainer CHARLES HILL?"

Answer:

1	Mary	Hinkle	555.123.4567
2	Paul	Litz	555.258.8963

Compiled by Rick Dobson
Graphics & Design by Fred Schneider

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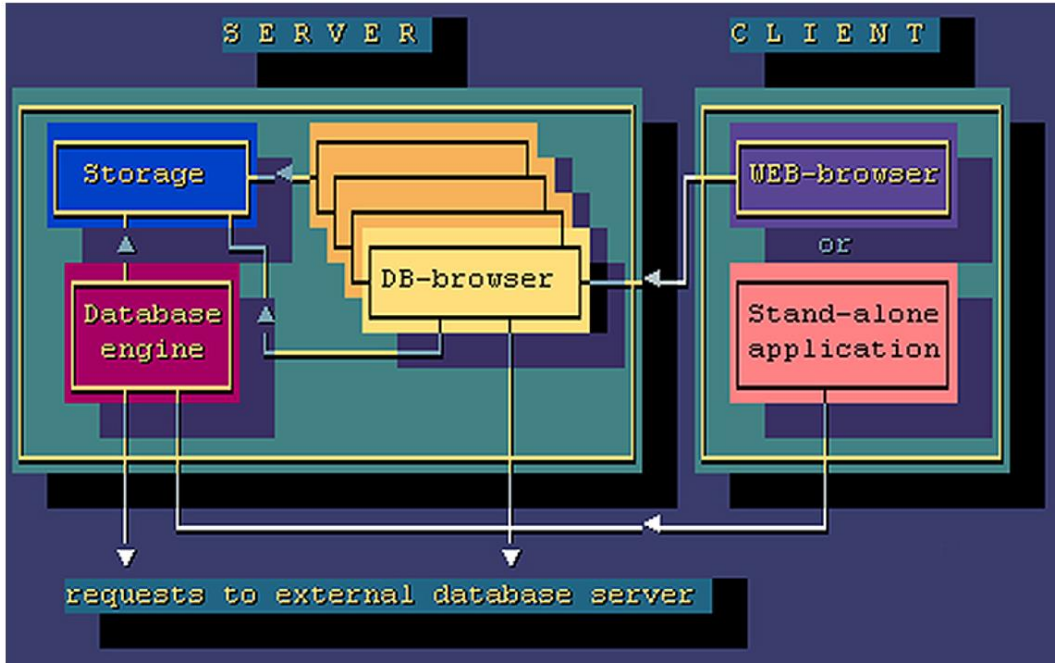
  - High-performance (for the era) transaction processing
  - Advent of DBMS

Database Management Systems



History of databases

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- 1980s
  - Research relational prototypes evolve into commercial systems
  - SQL („Structured Query Language“) becomes industrial standard
  - Parallel and distributed database systems
  - Object-oriented database systems

History of databases

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- 1990s:
  - Large decision support and data-mining applications
  - Large multi-terabyte data warehouses
  - Emergence of Web commerce

History of databases

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- 2000s
  - Big data storage systems
  - Google BigTable, Yahoo PNuts, Amazon,
  - “NoSQL” systems.
  - Big data analysis: beyond SQL

History of databases

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- 2010s
  - SQL reloaded
  - SQL front end to Map Reduce systems
  - Massively parallel database systems
  - Multi-core main-memory databases

What is a ...

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... database

- ... database management system (DBMS)?

Database Management System

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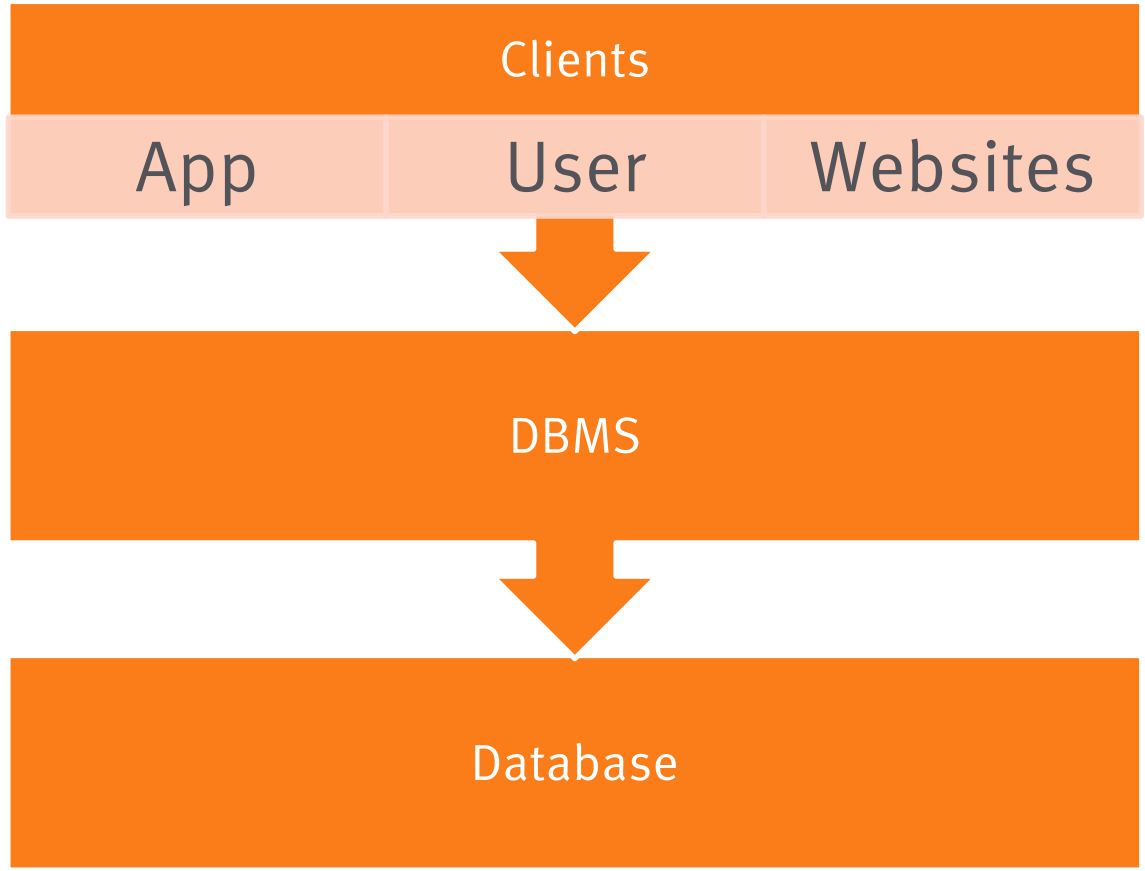
- interacts with apps and users
- interacts with database itself

- organizes data and its storage
- handles user requests
- assures data integrity
- enables scalability



Types of DBMS

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- Relational DBMS (RDBMS): These systems store data in table form and use relational models to manage the data relationships.
  - Examples include MySQL, PostgreSQL and Oracle.
- NoSQL DBMS: These systems are used when large amounts of unstructured data need to be managed, such as in big data applications.
  - Examples include MongoDB, Cassandra and Couchbase
- In-memory DBMS: These systems store data in the main memory instead of on hard disks, which enables very fast data access. They are often used in real-time applications, such as those required in the manufacturing industry for process monitoring.

Applications of DBMS

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smart home

industry

healthcare

AI

Introducing of SQL Games