In the Lecture Series Introduction to Database Systems

What's in a Database Course?

Presented by Stéphane Bressan

This Course

An **introductory** course on **databases**

First Lecture

We discuss the **rationale** and motivate and outline the **syllabus** of the course

Database Application

A database application is a collection of **data** and the **programs** that allow the manipulation of these data

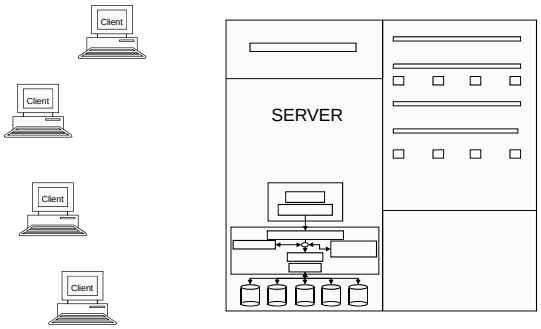
Database Application (Examples)

- Banking
- University
- Airline reservations
- My address book
- The e-shop around the corner

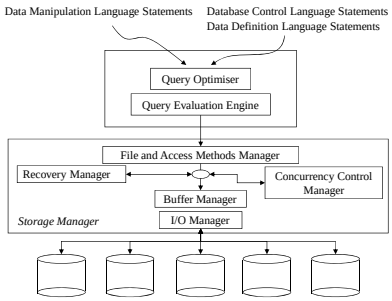
Database management Systems

- **Database Management Systems** (**DBMS**) are generic platforms for the **implementation** and **management** of database applications
  - Oracle
  - SQL Server
  - Sysbase
  - DB2
  - MySQL
  - SQLite
  - MS Access

DBMS Client/Server Architecture



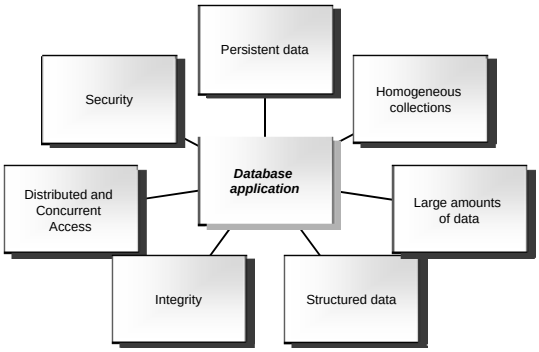
DBMS (simplified) Architecture



Why are we here?

Database is **not taught at MIT**

What is Specific about Database Applications?

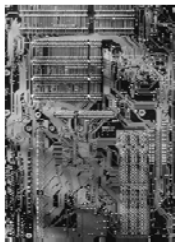


Data must Persist

How can data **survive** the process that created it, and be **reused** by other processes?

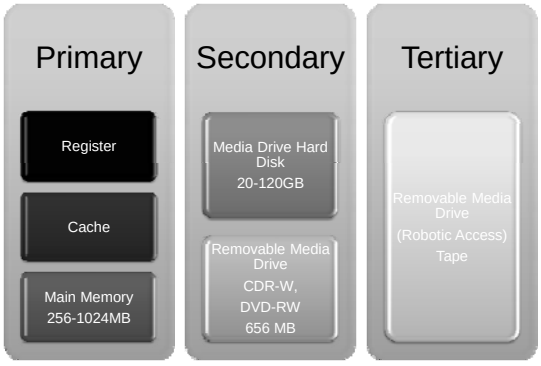
Data must Persist

Primary memory is **volatile**

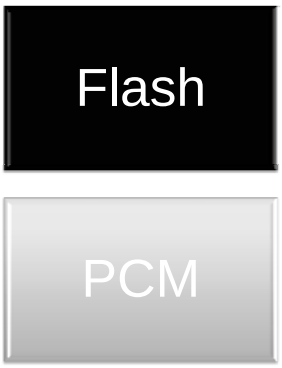


Secondary and **tertiary memories** are **persistent**

Data must Persist



Data must Persist



Data Comes in Large Amounts

- There were **176 million voters** in the 2009 Indonesian elections
- Where could one **store** the **names**, **identification numbers**, and **electoral districts** of voters?

Data Comes in Large Amounts

- There were **176 million voters** in the 2009 Indonesian elections
- How could one **sort them by alphabetical order** of electoral districts and names?

Data Comes in Large Amounts

When data is to be stored on secondary or tertiary storage, then we need to devise **efficient algorithms** taking into account the dominant cost of **Input/Output operations** (I/Os)

Such algorithms are called **external** algorithms (e.g., *external sort*)

Data Comes in Large Amounts

- There were **176 million voters** in the 2009 Indonesian elections
- Imagine the original tapes contain duplicate entries
- Think about an algorithm to remove the duplicate entries

Data Comes in Homogeneous Collections

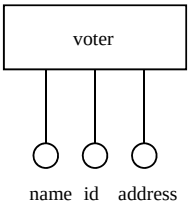


The Good News!

The DBMS implements

- **access methods**
- and **indexing** and **access methods** for efficient storage, update, and retrieval

Data is Structured



The Good News!

- The DBMS supports **data models**

We can **design** applications around the data by defining the application **schema**

- The DBMS supports **languages** for data **definition** and **manipulation**

We can **program** applications using dedicated languages such as **SQL**

Nothing New Under the Sun…

in the late 1990s, a report from the Gartner Group estimated that eighty percent of existing code was written in COBOL

Data is Structured: the Good News!

- DDL: **Data Definition Language**. It includes statements to define the schema

declare structure

- DML: **Data Manipulation Language**. It includes statements for creating, updating, and querying data

manipulate data

Data is Structured

```
CREATE TABLE voters
        (first_name char(32),
        last_name CHAR(32),
        district CHAR(64),
        national_id NUMBER)

SELECT last_name
  FROM voters
  WHERE first_name = 'Bambang'
```

DDL
sql is not case sensitive

DML

Transactions

A **transaction** is a **logical unit of work** carried out by a user or an application

Integrity of Data should be Maintained

How to maintain the integrity of data in spite of possible **application**, **system**, or **media failures**?

Consistent States

A **consistent state** of the database is a state which complies with the business rules as usually defined by **integrity constraints**

"students who have not passed cs2102 cannot take cs3223"

Distributed and Concurrent Access

How can data be **shared** by users and processes that are possibly **distributed** over a network?

Recovery

- **Atomicity:** all actions in a transaction happen or none happen
- **Durability:** effects of successful transactions last

Concurrency Control

- **Isolation:** Transactions can be understood independently from each other
- **Consistency:** If individual transactions would leave the application in a consistent state, a concurrent execution should do the same

ACID Properties of Transactions

- Concurrency Control: *A**CI**D*
  - Isolation
  - Consistency:
- Recovery: **A***C**I***D**
  - Atomicity
  - Durability

Security and Access Control of Data is Critical

How to protect the data and define and **control** **access** to data?

Definitions

- DCL: **Database Control Language**. It include statements to administer access privileges and transactions properties

In Summary

A database application manages **homogeneous collections** containing **large amounts** of **persistent** **structured data** that are **shared** among **distributed** users and processes and whose **integrity** must be maintained and **security** controlled

Conclusion

- We have **identified the typical requirements** of database applications
- We have **identified Database Management Systems** as the platforms for database applications
- We have **identified the topics to study** in this course: design and programming

Syllabus

- **Design**
  - Entity Relationship Model
  - Relational Model
  - Normalisation with Functional Dependencies
- **Programming**
  - Theory of Query Languages: algebra and calculi
  - SQL
  - SQL and Programming Languages

Credits

The content of this lecture is based on chapter 1 of the book "Introduction to database Systems" By S. Bressan and B. Catania, McGraw Hill publisher

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