Databases

Databases

- **ABSTRACT**
  - The aim of this course is to introduce students to database concepts and database management systems (DBMS).
  - Before exploring databases and the objectives associated with dbmss, students will be given an overview of the different ways of organizing and exploiting files.
  - In reference to ANSI-SPARC Architecture, this course will define the different levels used for describing a database (conceptual, logic model and physical).
  - Next, students will study the entity-relationship model, then, in a little more detail, the CODD relational model with an emphasis on good database schema design.
  - Students will discover how to move from an entity-relational model to a relational model as well as the creation and manipulation of data in the latter through the use of relational algebra.
  - SQL will also be used to create, populate and consult databases.

Databases

- **OUTLINE**
  - ANSI-SPARC Architecture; relational algebra; database manipulation; SQL
- **KEYWORDS**
  - Merise; ER model; MCD; MLD; relational model; DMBS; SQL; DDL; DML; JOIN
- **PREREQUISITES**
  - Students should have a basic understanding of computer sciences.
- **LEARNING OUTCOMES**
  - Students will be able to design, implement and manipulate a database.
- **LEARNING MATERIALS**
  - Powerpoint slides; software (SGBD Oracle)

Databases

Basic concepts

- Database
- DBMS – Database Manegement Systems

- Relational databases
- Search for information - SQL language
- Database design and implementation

Literature

- **A.Silberschatz, H.F. Korth, S. Sudarshan,**
  "Database System Concepts", McGrow Hill, 2010.
  - http://www.db-book.com/
- **H.Garcia-Molina, J.Ullman, J.Widom**
  „Database Systems The Complete Book", Prentice Hall, 2008.
  - www-db.stanford.edu
  - http://infolab.stanford.edu/~ullman/dscb.html
- **Ramakrishan R., Gehrke J**
  Database Management Systems , mcgraw-Hill, 2010

- **Eric Redmond, Jim R. Wilson**
  Seven Databases in Seven Weeks: A Guide to Modern Databases and the NoSQL Movement, 2012

Literatre

- **M. Gertz, Oracle/SQL Tutorial (available online)**
- **SQL Tutorial,**
  - http://www.w3schools.com/sql/
- **Introduction to Databases - Stanford Online**
  - https://class.stanford.edu/courses/Home/Databases/Engineering/about
- **Database fundamentals**
  - http://channel9.msdn.com/Series/dbfundamentals/01

- **Wilfried Lemahieu, Seppe vanden Broucke, Bart Baesens „Principles of Database Management**
  - https://www.youtube.com/watch?v=o36Z_OqC2ac&list=PLdQddgMBv5zHcEN9RrhADq3CBColhY2hl

- **Slideds based on:**
  - Database System Concepts
    Avi Silberschatz, Henry F. Korth, S. Sudarshan
    http://www.db-book.com/

Outline

- The Need for Databases
- Data Models
- Relational Databases
- Database Design
- Storage Manager
- Query Processing
- Transaction Manager

Database-System Applications

- **DBMS contains information about a particular enterprise**
  - Collection of interrelated data
  - Set of programs to access the data
  - An environment that is both *convenient* and *efficient* to use
- **Database systems are used to manage collections of data that are:**
  - Highly valuable
  - Relatively large
  - Accessed by multiple users and applications, often at the same time.
- **A modern database system is a complex software system whose task is to manage a large, complex collection of data.**
- **Databases touch all aspects of our lives**

Database Applications Examples

- **Enterprise Information**
  - Sales: customers, products, purchases
  - Accounting: payments, receipts, assets
  - Human Resources: Information about employees, salaries, payroll taxes.
- **Manufacturing: management of production, inventory, orders, supply chain.**
- **Banking and finance**
  - customer information, accounts, loans, and banking transactions.
  - Credit card transactions
  - Finance: sales and purchases of financial instruments (e.g., stocks and bonds; storing real-time market data
- **Universities: registration, grades**

Database Applications Examples (Cont.)

- **Airlines: reservations, schedules**
- **Telecommunication: records of calls, texts, and data usage, generating monthly bills, maintaining balances on prepaid calling cards**
- **Web-based services**
  - Online retailers: order tracking, customized recommendations
  - Online advertisements
- **Document databases**
- **Navigation systems: For maintaining the locations of varies places of interest along with the exact routes of roads, train systems, buses, etc.**

Purpose of Database Systems

- **In the early days, database applications were built directly on top of file systems, which leads to:**
  - Data redundancy and inconsistency: data is stored in multiple file formats resulting induplication of information in different files
  - Difficulty in accessing data
    - Need to write a new program to carry out each new task
  - Integrity problems
    - Integrity constraints (e.g., account balance > 0) become “buried” in program code rather than being stated explicitly
    - Hard to add new constraints or change existing ones.

Purpose of Database Systems (Cont.)

- **Atomicity of updates**
  - Failures may leave database in an inconsistent state with partial updates carried out
  - Example: Transfer of funds from one account to another should either complete or not happen at all
- **Concurrent access by multiple users**
  - Concurrent access needed for performance
  - Uncontrolled concurrent accesses can lead to inconsistencies
    - Ex: Two people reading a balance (say 100) and updating it by withdrawing money (say 50 each) at the same time
- **Security problems**
  - Hard to provide user access to some, but not all, data

Database systems offer solutions to all the above problems

View of Data

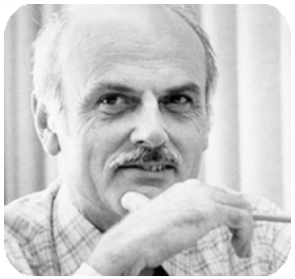
- **A database system is a collection of interrelated data and a set of programs that allow users to access and modify these data.**
- **A major purpose of a database system is to provide users with an abstract view of the data.**
  - Data models
    - A collection of conceptual tools for describing data, data relationships, data semantics, and consistency constraints.
  - Data abstraction
    - Hide the complexity of data structures to represent data in the database from users through several levels of data abstraction.

Data models

- **Data Model - a collection of tools for describing**
  - Data
  - Data relationships
  - Data semantics
  - Data constraints
- **Various data models**
  - Relational model
  - Entity-Relationship data model (mainly for database design)
  - Object-based data models (Object-oriented and Object-relational)
  - Semi-structured data model (XML)
  - Other older models:
    - Network model
    - Hierarchical model
    - NoSQL

Relational Model

- All the data is stored in various tables.
- Example of tabular data in the relational model



Ted Codd
Turing Award 1981

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
10101	Srinivasan	Comp. Sci.	65000
58583	Califieri	History	62000
83821	Brandt	Comp. Sci.	92000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

(a) The *instructor* table

A Sample Relational Database

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
10101	Srinivasan	Comp. Sci.	65000
58583	Califieri	History	62000
83821	Brandt	Comp. Sci.	92000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

(a) The *instructor* table

dept_name	*building*	*budget*
Comp. Sci.	Taylor	100000
Biology	Watson	90000
Elec. Eng.	Taylor	85000
Music	Packard	80000
Finance	Painter	120000
History	Painter	50000
Physics	Watson	70000

(b) The *department* table

SQL

- **SQL query language is nonprocedural. A query takes as input several tables (possibly only one) and always returns a single table.**
- **Example to find all instructors in Comp. Sci. dept**

  select *name*
  from *instructor*
  where *dept_name* = 'Comp. Sci.'

- **SQL is NOT a Turing machine equivalent language**
- **To be able to compute complex functions SQL is usually embedded in some higher-level language**
- **Application programs generally access databases through one of**
  - Language extensions to allow embedded SQL
  - Application program interface (e.g., ODBC/JDBC) which allow SQL queries to be sent to a database