# Database Management Systems (LIX022B05)

Instructor: Çağrı Çöltekin
c.coltekin@rug.nl

Information science/Informatiekunde

September 2, 2013



## Who, where, when

| | |
|---|---|
| Course | Databases (LIX022B05) 2013/14 |
| Instructor | Çağrı Çöltekin |
| Email | c.coltekin@rug.nl |
| Lectures | Mon 11:00–13:00, `1315.0031` |
| Labs | Fri 11:00–13:00, `1312.0107A` |
| Office hours | Wed 15:00–17:00, `1311.0426` |
| Course page | `http://www.let.rug.nl/coltekin/courses/db2013` |





## Literature

Textbook:
*Database System Concepts* by A. Silberschatz, H. F. Korth and S. Sudarshan. McGraw-Hill (2010), ISBN 978-007-128959-7 (6th international ed.)

More References:

- *Database Management Systems* by Ramakrishnan & Gehrke
- *A First Course in Database Systems* by Ullman & Widom
- *Fundamentals of Database Systems* by Elmasri & Navathe
- *Database Systems: The Complete Book* by Garcia-Molina, Ullman & Widom
- *Database Systems: A Practical Approach to Design, Implementation, and Management* by Connolly & Begg





## Evaluation

Grading:

| | |
|---|---|
| Homework/lab assignments | 30% |
| Final exam (Tentamination) | 70% |

Homework assignments:

- Six lab/homework assignments: a homework each week (except this week)
- Homeworks will be a combination of theory + practice (mostly SQL).
- You have a week for each homework. Late homeworks up to one week receive half credit. no extensions!
- Submit your homeworks through Nestor, as a single PDF file.
- Evaluation will be based on best five homework scores.





## Lab Sessions

Homework assignments:

- You need an accounts on siegfried.webservice.rug.nl and mysql01.service.rug.nl. If you do not have an account apply to
  `A. da Costa`
  `Room: 1313.336`
  `Mo-Thu, 10:30-12:00 and 14:00-15:30`
- No programming, mostly exercises with SQL.





## About this course

This is an *introductory* course on database management systems. The particular focus will be on relational database management systems.

- No initial knowledge of databases required.
- There is no programming in this course.
- We will have a practical focus, but the theories behind the relational database design practices and queries are also introduced.





## After this course

You should be able to

- develop a conceptual data model that reflects an organization's database requirements
- convert the conceptual data model into a relational database schema
- apply normalization techniques
- identify data integrity and security requirements
- be able to construct complex SQL queries
- be familiar with fundamentals of database administration, performance and optimization
- gain hands-on experience with a database management system (MySQL)





## Time plan

| Week | Lecture (Monday) | Lab (Friday) |
|---|---|---|
| 1 | Introduction | No Lab this week. |
| 2 | Conceptual DB design, E-R diagrams | DB Design with E-R diagrams |
| 3 | Logical DB design, normalization | Implement a DB in MySQL |
| 4 | SQL 1: simple queries | Query exercises |
| 5 | SQL 2: more complex queries | More query exercises |
| 6 | SQL 3:views, indexes, access control | Indexes, views, access control. |
| 7 | SQL and programming & Summary | A set of exercises on all subjects |

## Next (for some of you)...

Next half-semester course 'Database-driven web technology', will cover:

- A more practical approach to the subjects in this course.
- Some programming for web applications (PHP).
- Using relational databases from web applications.
- More/practical topics including
  - transaction processing
  - security
  - performance





## Today

- What is a database? and database management system (DBMS)?
- Why use a DBMS?
- Why not use a DBMS?
- Ways of organizing data
- Common DB architectures
- A quick introduction to RDBMSs: tables, keys, queries.





## What is a database?

A *database* is a collection of related data.

- A company database: employees, departments, salaries, ...
- A bank database: customers, accounts, loans, credits, ...
- Airline flight reservation database: flights, seats, tickets, ...
- A library catalog: books, authors, ...
- University student database: students, instructors, grades, ...
- A database of DNS records: domain names, IP addresses, ...
- The collection of documents in Wikipedia: documents, authors, revisions, ...
- The phone book on your mobile phone: contacts, phone numbers, email addresses, ...
- ...





## What is a database management system?

A database management system (DBMS) is a *general purpose* software system for *creating*, *maintaining* and *sharing* data.

A DBMS,

- allows creating a database
- allows populating the database and manipulating the data
- enables queries on the data stored in the database
- enforces data integrity
- provides data access control





## Why use a DBMS

- Insulation between program and data
- Multiple views of the same data
- Sharing data in multi-user environments
- Controlling redundancy
- Enforcing data integrity
- Access control
- Efficient query processing
- Backup and recovery
- Multiple user interfaces





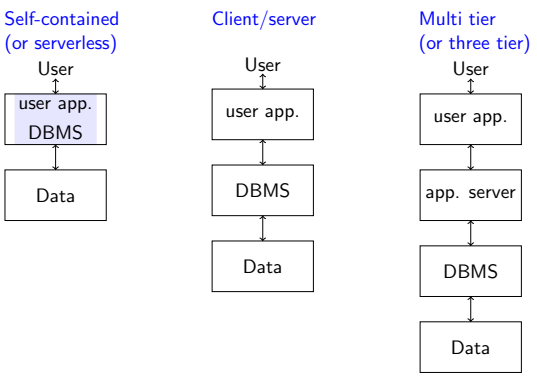
## Why not use a DBMS?

- The overhead of DBMS
- Specialized data access
- Cost of DBMS
- Simple and well-defined read-only data
- Real-time systems
- Single-user environments.





## DBMS architectures








## Typical roles in a DBMS environment

- User
- Application programmer
- Database designer
- Database administrator

## Relational DBMSs

In this course we will focus on *relational* database management systems (RDBMS), where data and the relations between the data is organized in the form of *tables* (or, relations).

**Book**

| *ISBN* | *title* | *year* | *pages* |
|---|---|---|---|
| 0330258648 | The Hitchhiker's Guide to the Galaxy | 1979 | 180 |
| 055338256X | I, Robot | 1950 | 272 |
| 0553383043 | A Wizard of Earthsea | 1968 | 192 |

**Author**

| *name* | *ISBN* |
|---|---|
| Douglas Adams | 0330258648 |
| Isaac Asimov | 055338256X |
| Ursula K. LeGuin | 0553383043 |

**Genre**

| *genre* | *author* |
|---|---|
| comedy | 0330258648 |
| sci-fi | 0330258648 |
| fantasy | 0553383043 |





## Types of DBMSs

Relational data model and RDBMSs are the dominant method of modeling and managing databases. However, it is not the *only* way. Historical precursors:

- Hierarchical
- Network

Somewhat new:

- Object-oriented or object-relational

.. and becoming popular:

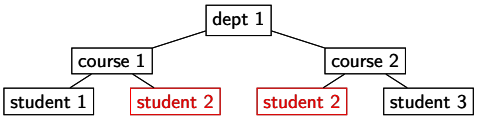
- So-called NoSQL databases covering a wide range of methods of organizing data.





## Hierarchical databases

Initial DBMSs followed a *hierarchical* data organization. All records in a hierarchical database is organized according to a hierarchy.




Main problem: data replication.

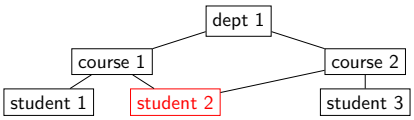
Although this is a serious problem for typical database applications. The hierarchical databases are preferable, and still popular, for certain applications (e.g. DNS, LDAP).





## Network databases

To overcome the replication problem with the hierarchical databases, network databases allow arbitrary links (representing relations) between the data records.




Main problem: complexity.





## Object-based databases

With the popularity of object-oriented programming languages, object oriented database management systems are suggested.

Object relational: extension of relational database systems to support object-oriented notions like user-defined data types, inheritance, encapsulation etc.

Object oriented: supports objects from an object-oriented programming language to be stored in a database.

The object-based databases are still not standardized, and relational databases are still the dominant approach to standard database applications.





## NoSQL databases

A large range of database management system that are collectively called *NoSQL* databases has (re)gained popularity in recent years. Examples include:

- Key-value stores (Berkeley DB)
- Document stores (Apache CouchDB)
- Graph (FlockDB)
- Tabular (Google BigTable)
- Tuple store (Apache River)





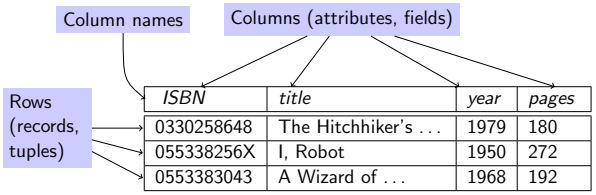
## Structure of a relational database

- A relational database consists of multiple relations, or tables.
- Information is broken into multiple tables.
- The relevant information is accessed through references between tables.
- A bad database design results in problems such as data replication, or inconsistency.





## Anatomy of a table (or relation)




- Domain of an attribute is the set of allowed values the attribute can take.

## More on relations

| *ISBN* | *title* | *year* | *pages* |
|---|---|---|---|
| 0330258648 | The Hitchhiker's Guide to the Galaxy | 1979 | 180 |
| 055338256X | I, Robot | 1950 | 272 |
| 0553383043 | A Wizard of Earthsea | 1968 | *null* |

- No two rows are identical.
- Order of rows and columns are not important. (NB. order may be important in some SQL statements)
- A domain is said to be *atomic* if the elements of the domain are considered indivisible.
- A special value '**null**' is allowed for unknown or inapplicable values.





## Primary Key

| *ISBN* | *title* | *year* | *pages* |
|---|---|---|---|
| 0330258648 | The Hitchhiker's Guide to the Galaxy | 1979 | 180 |
| 055338256X | I, Robot | 1950 | 272 |
| 0553383043 | A Wizard of Earthsea | 1968 | 192 |

A primary key, formed by one or more attributes, uniquely identifies any (potential) row in the table.

- In worst case, the values of all attributes in a row has to be unique.
- A *candidate key* is one with no redundant attributes.
- There may be more than one candidate keys. Choice of primary key is a database design decision.





## Foreign Key

| Book | | | |
|---|---|---|---|
| *ISBN* | *title* | *year* | *pages* |
| 0330258648**0330258648** | The Hitchhiker's Guide to the Galaxy | 1979 | 180 |
| 055338256X**055338256X** | I, Robot | 1950 | 272 |
| 0553383043**0553383043** | A Wizard of Earthsea | 1968 | 192 |

| Genre | |
|---|---|
| *genre* | *ISBN* |
| comedy | 0330258648**0330258648** |
| sci-fi | 0330258648**0330258648** |
| sci-fi | 0553383043**0553383043** |

| Author | |
|---|---|
| *name* | *ISBN* |
| Douglas Adams | 0330258648**0330258648** |
| Isaac Asimov | 055338256X**055338256X** |
| Ursula K. LeGuin | 0553383043**0553383043** |

A foreign key is used for cross-referencing in a RDBMS. The set of attributes that form the foreign key in a (referencing) table is the primary key of another (referenced) table.





## Languages for creating, changing, querying

- Data Definition Language (DDL) allows creating relations that form a database.
- Data Manipulation Language (DML) allows changing the data in the database.
- A query language allows finding specific information in the database.

The *the* standard language for all above purposes (and more) is called *SQL*. Others exist (e.g. QBE), but SQL is the language supported by all main RDBMSs.





## SQL: create/drop table

To create a table:

**create table** table_name (attribute$_1$ domain$_1$, ..., attribute$_N$ domain$_N$, (constraint$_1$), ... (constraint$_m$));

Example:

```
create table book (ISBN    int,
                   title   varchar(50),
                   year    int,
                   pages   varchar(50),
                   primary key (ISBN));
```

To drop (remove) a table:

**drop table** table_name;

Example:

```
drop table book;
```





## SQL: insert/delete records

To insert a new record:

**insert into** table_name (attribute$_1$, ... attribute$_N$)
**values** (value$_1$, ... value$_N$);

Example:

```
insert into book
    values ('055338256X', 'I Robot',
            1950, 272);
```

To remove record(s):

**delete from** table_name **where** condition;

Example:

```
delete from book where ISBN = '055338256X';
```





## SQL: update records

**update** table_name
**set** attribute$_1$=value$_1$, ..., attribute$_N$=value$_N$
**where** condition;

Example:

```
update book set title='I Robot'
    where ISBN='055338256X';
```





## SQL: queries

**select** attribute$_1$, ..., attribute$_N$
**from** table$_1$, ..., table$_M$
**where** condition;

Examples:

```
select ISBN, title from book
    where year > 1960;

select * from book
    where ISBN='055338256X';
```

## Summary / Next week

Today:

- A general introduction to databases and database management systems, relational databases and SQL.
- We will return to (almost) all subjects introduced today in later weeks.

Friday:

- No lab this week.
- Obtain server accounts (see slide 9), or check whether you already have one.

Next Week:

- Conceptual database design.
- Read Chapter 7. (We will not study Section 7.8 about extended E-R features).