Database Management Systems (LIX022B05)

Instructor: Çağrı Çöltekin

c.coltekin@rug.nl

Information science/Informatiekunde

Fall 2012

Who, where, when

Course	Databases (LIX022B05) 2012/13
Instructor	Çağrı Çöltekin
Email	c.coltekin@rug.nl
Lectures	Mon 13:00–15:00, `A weg 30, room 103`
Labs	Wed 15:00–17:00, `1312.0107 MB`
Office hours	Wed 13:00–15:00, `H1311.0426`
Course page	`http://www.let.rug.nl/coltekin/db2012/`

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:

Homeworks & labs	30%
Final exam (Tentamination)	70%

Homework assignments:

- Six homeworks: a homework each week (except this week)
- Homeworks will be combination of theoretical questions with some practical (mostly SQL) exercises.
- Practical part of the homeworks will be related to the lab exercises.
- You have a week for each homework: no extensions!
- Evaluation will be based on best five homework scores.

Lab Sessions

Homework assignments:

- You need an account on siegfried.let.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`
- You also need a MySQL user account and a database for the exercises.
- 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 (Mon)	Lab (Wed)
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 ...	Query optimization, Indexes, DBA tasks
7	Summary & introduction to SQL and programming	Q&A

Next...

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.

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.

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

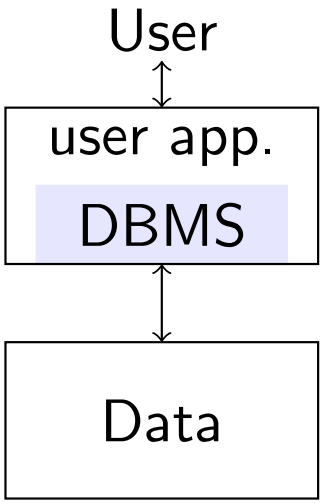
- Controlling redundancy
- Enforcing data integrity
- Access control
- Efficient query processing
- Backup and recovery
- Multiple user interfaces

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

Self-contained
(or serverless)

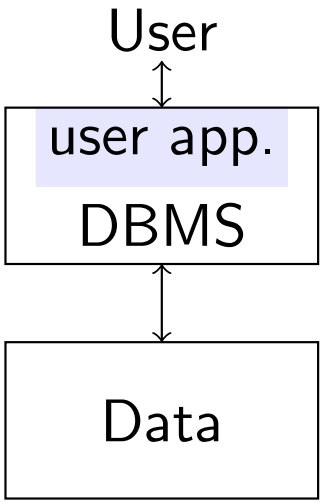


Client/server

Multi tier
(or three tier)

DBMS architectures

Self-contained
(or serverless)

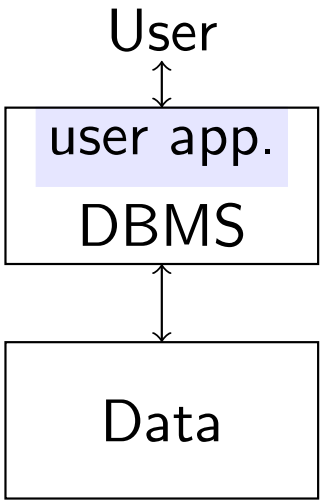


Client/server

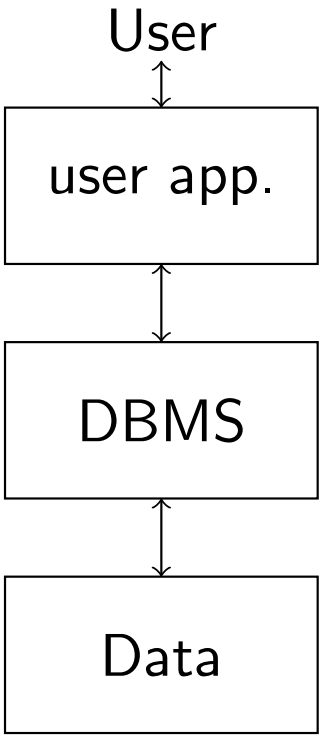
Multi tier
(or three tier)

DBMS architectures

Self-contained (or serverless)



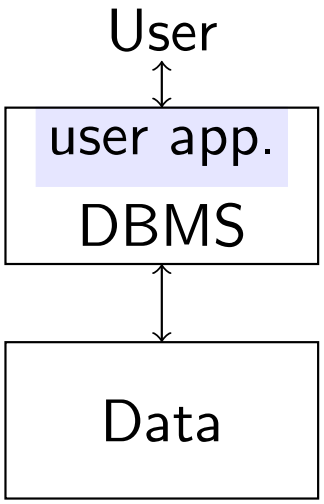
Client/server



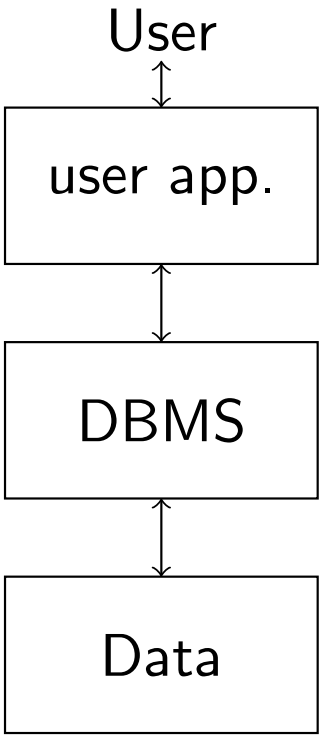
Multi tier (or three tier)

DBMS architectures

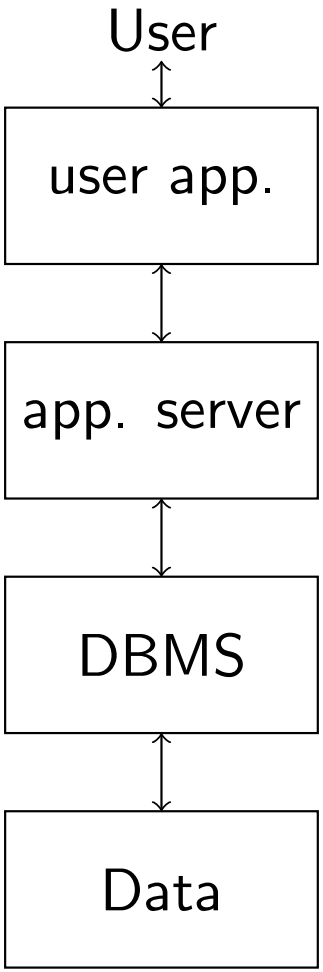
Self-contained (or serverless)



Client/server



Multi tier (or three tier)



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:

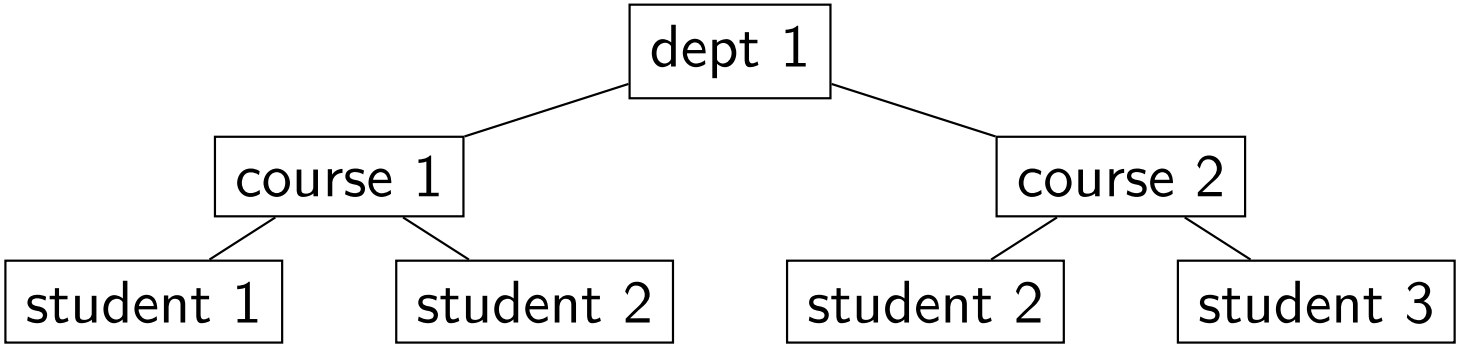
- Object-oriented or object-relational

.. and becoming popular:

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

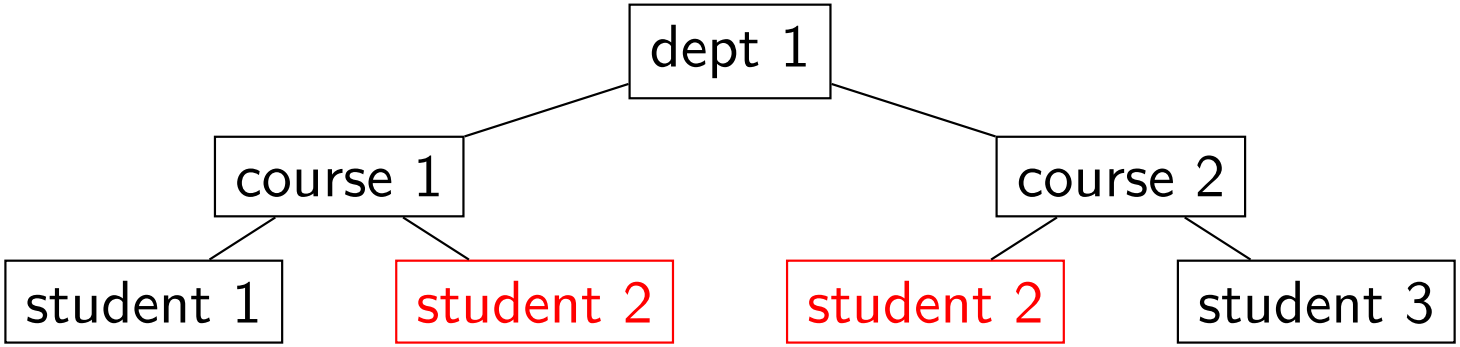
Hierarchical databases

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



Hierarchical databases

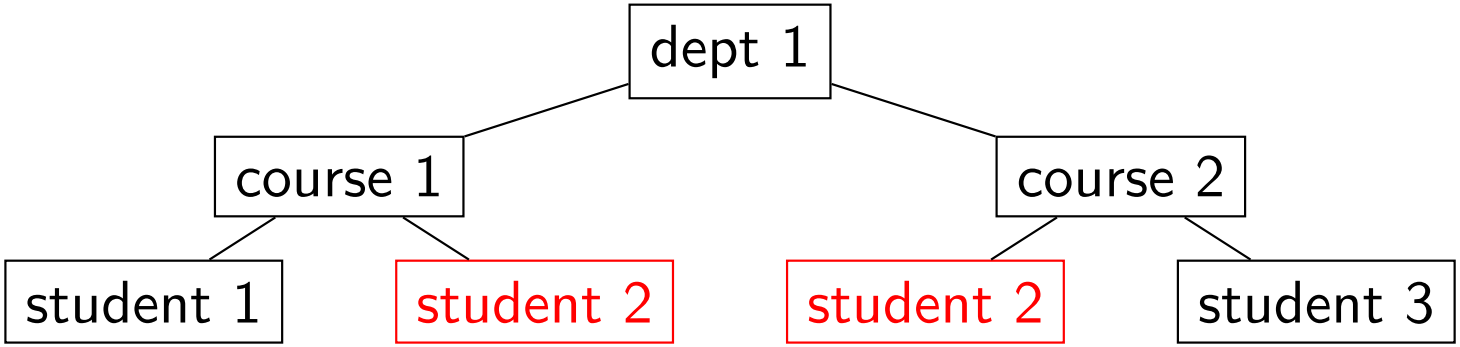
Initial DBMSs followed a *hierarchical* data organization. All records in a hierarchical database is organized according to a hierarchy.



Main problem: data replication.

Hierarchical databases

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

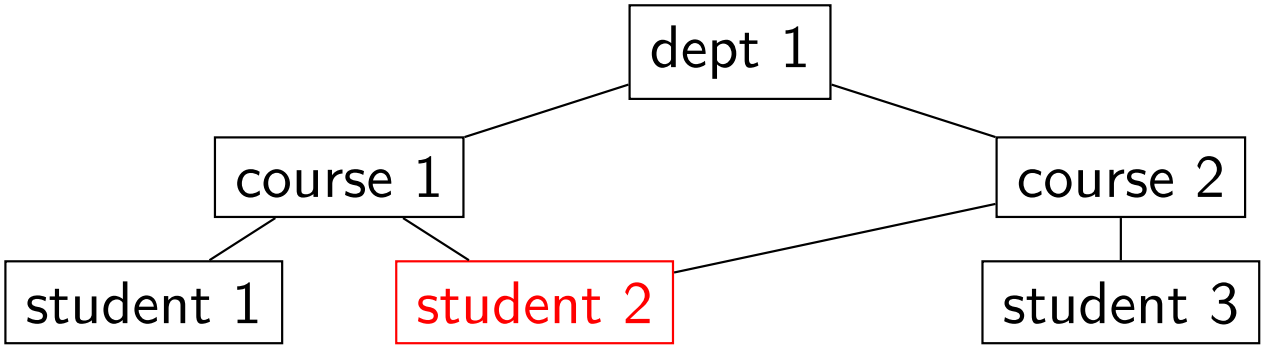


Main problem: data replication.

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).

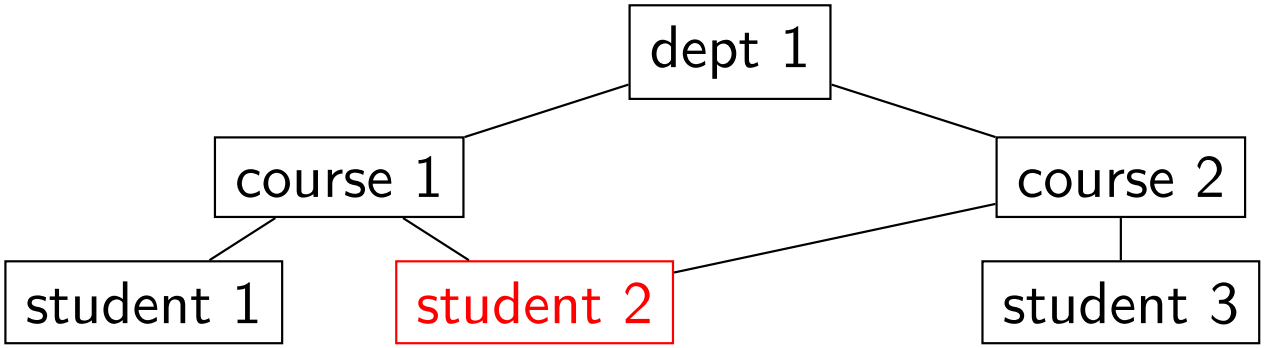
Network databases

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



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.

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)

Column names

Columns (attributes, fields)

Rows (records, tuples)

ISBN	*title*	*year*	*pages*
0330258648	The Hitchhiker's ...	1979	180
055338256X	I, Robot	1950	272
0553383043	A Wizard of ...	1968	192

- 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 a row in a 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	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	*ISBN*
comedy	0330258648
sci-fi	0330258648
sci-fi	0553383043

Foreign Key

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	*ISBN*
comedy	0330258648
sci-fi	0330258648
sci-fi	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));
```

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);
```

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 $\text{attribute}_1 = \text{value}_1, \ldots, \text{attribute}_N = \text{value}_N$
  where condition;

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 $\text{attribute}_1, \ldots, \text{attribute}_N$
from $\text{table}_1, \ldots, \text{table}_M$
where condition;

SQL: queries

select $\text{attribute}_1, \ldots, \text{attribute}_N$
from $\text{table}_1, \ldots, \text{table}_M$
where condition;

Examples:

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

select * from instructor
    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.

Wednesday:

- No lab this week.
- Obtain a database account on siegfried, or check if you already have one.

Next Week:

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