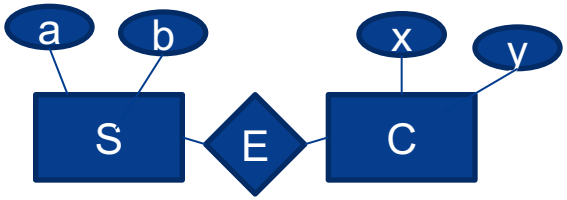
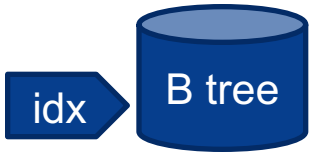
# Relational Model to the DBMS (via SQL DDL)

Data can be represented at different levels of abstraction




S (a,b,…)
C (x,y,…)




Conceptual Schema → Logical Schema → Physical Schema

ER:
- Entities,
- Relationships,
- Attributes

Not specifically tied to a database

Relations:
- tuples,
- attributes
- domain

≈ Tables/columns/rows

specifically tied to the data model of a database you chose (for our course, the choice is relational database)

File organisation:
- File types
- Index structures

specifically tied to the implementation
Methods provided by the database you chose

# What is RDBMS?

A *relational database management system* (RDBMS) is

- software designed to support large-scale data-intensive applications
- **allowing high-level description of data (tables, constraints)**
- **with high-level access to the data (relational model, SQL)**
- providing efficient storage and retrieval (disk/memory management)
- supporting multiple simultaneous users (privilege, protection)
- doing multiple simultaneous operations (transactions, concurrency)
- maintaining reliable access to the stored data (backup, recovery)

Note: databases provide *persistent* storage of information

# Describing Data – SQL language

Relational Database Management Systems (RDBMS) implement ≅ the relational model.

SQL provides the high-level access to describing and accessing data

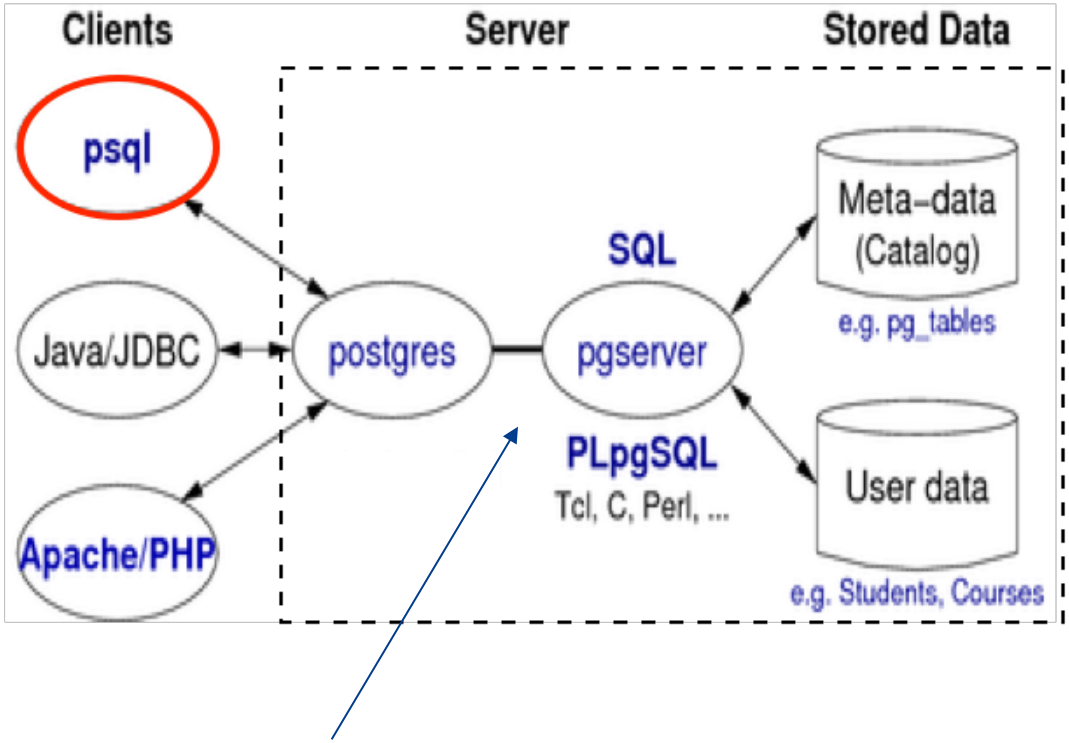
In RDBMS, Using SQL, one can define:

- domains, attributes, tuples, tables
- constraints (domain, key, referential)

Variations from the relational model:

- no strict requirement for tables to have keys
- bag semantics, rather than set semantics
  - set: no order, without duplicates vs. bag: no order, with duplicates
  - *if no key is defined in an SQL table, duplicate tuples can exist*
- no standard support for general (multi-table) constraints
  - *use advanced concepts like triggers instead*

# PostgreSQL client-server architecture




- Originally "Structured Query Language", today a proper name
- A language with several functionalities, comprises of :
  - DDL (Data Definition Language)
  - DML (Data Manipulation Language)
- There exists several standards, and companies have added proprietary extensions

# Managing Databases

Shell commands:

- **createdb** *dbname*
- **dropdb** *dbname*

(If no *dbname* supplied, assumes a database called *YOU*)

SQL DDL (Data Definition Language) statements (inside dbname)

- **CREATE TABLE** *table* **(** *Attributes+Constraints* **)**
- **ALTER TABLE** *table* *TableSchemaChanges*
- **DROP TABLE** *table(s)* [ **CASCADE** ]
- **COPY** *table* **(** *AttributeNames* **) FROM STDIN**
- **INSERT INTO** *table* **(** *attrs* **) VALUES** *tuple(s)*
- **DELETE FROM** *table* **WHERE** *condition*
- **UPDATE** *table* **SET** *AttrValueChanges* **WHERE** *condition*

# Data Definitions in SQL

CREATE TABLE

- Defines a relation schema (with attributes and integrity constraints)
- Creates an empty instance of the schema

```
create table Employee (
   EmpNo            char(6) primary key,
   FirstName        varchar(20) not null,
   LastName         varchar(20) not null,
   Dept             varchar(15),
   Salary           numeric(9) default 0,
   City             varchar(15),
   foreign key(Dept) references Department(DeptName),
   unique (LastName,FirstName)
)
```

# Domains

**Elementary domains or types (predefined)**

- Character: single characters or strings → both of fixed and variable length
- Bitstrings: string elements are 0 and 1
- Numbers: integers and reals
- Dates, timestamps, time intervals
- Introduced in SQL:1999
  - Boolean
  - BLOB, CLOB (binary/character large object): for large images or texts
- In some systems, enumeration types can be defined

**User defined domains (reusable)**

# Domain Definitions

**User defined domains**

`create domain`

1) defines a (simple) domain with integrity constraints and defaults, which can be reused in table definitions.
2) data types based on a constrained version of an existing data type;

**Example**:

```
create domain EmployeeAge

as smallint default null

check ( value >=18 and value <= 67 )
```

```
create table Employee (
   EmpNo        char(6) primary key,
   Age          EmployeeAge,
   Name         varchar(20),
…)
```

# Constraints on a Relation

**`not null`** (on single attributes)

**`unique`**: allows one to define a (candidate) key:

- on *single attribute*
- on *several attributes* (i.e., one or more): unique ($Attr_1$,..., $Attr_n$)

**`primary key`**: definition of the primary key (implies not null)

```
create table Employee (
   EmpNo              char(6) primary key,
   FirstName          varchar(20) not null,
   LastName           varchar(20) not null,
   Dept               varchar(15),
   Salary             numeric(9) default 0,
   City               varchar(15),
   foreign key (Dept) references Department(DeptName),
   unique (LastName,FirstName)
)
```

# Primary key – two ways to define it …

```
create table Employee (
    EmpNo               char(6) primary key,
    FirstName           varchar(20) not null,
    LastName            varchar(20) not null,
    Dept          varchar(15),
    Salary              numeric(9) default 0,
    City          varchar(15),
    foreign key (Dept) references Department(DeptName),
    unique (LastName,FirstName)
)
```

```
create table Employee (
    EmpNo               char(6),
    FirstName           varchar(20) not null,
    LastName            varchar(20) not null,
    Dept          varchar(15),
    Salary              numeric(9) default 0,
    City          varchar(15),
    primary key (EmpNo),
    foreign key (Dept) references Department(DeptName),
    unique (LastName,FirstName)
```

# Candidate keys: mind the step!

```
create table Employee ( ...
   FirstName  varchar(20) not null,
   LastName   varchar(20) not null,
   unique (LastName,FirstName)
)
```

is different from:

```
create table Employee ( ...
   FirstName  varchar(20) not null unique,
   LastName   varchar(20) not null unique
)
```

# Constraints Between Relations

**references** and **foreign key** allow one to define referential integrity constraints.

Syntax:

- for single attributes:

  references after the specification of the domain

- for several attributes:

  foreign key($Attr_1$,...,$Attr_n$) references ...

The referenced attributes in the target table must form a key (primary key or unique). If they are missing, the foreign key refers to the primary key of the target table.

Semantics: every combination (not involving NULL) of attribute values in the source table must appear in the target table.

It is possible to add policies that specify how to react to constraint violations (which are caused by changes of the target table).

# Constraints Between Relations

```
create table Student(
 StudNo  character(10) primary key,
 Name    character(20),
 Hons    character(3),
 Tutor   character(20) references Staff(Lecturer),
 Year    smallint)

create table Staff(
 Lecturer  character(20) primary key,
 RoomNo    character(4),
 Appraiser character(20),
 foreign key (Appraiser) references
             Staff(Lecturer)
             on delete set null
             on update cascade)
```

# Policies

Determine the effect of delete and update statements

Syntax

- `on delete` *`Action`*

  where *Action* can be

  | | |
  |---|---|
  | cascade | (propagate the deletion) |
  | restrict | (do nothing if the row is referenced) |
  | no action | (as restrict, but return an error) |
  | set default | |
  | set null | |

The same actions exist for updates (on update)

# Schema Updates

`alter domain:` allows one to modify a domain definition

`alter table:` allows one to modify a table

- add or drop attributes
- add or drop constraints

`drop domain:` eliminates a domain

`drop table:` eliminates a table