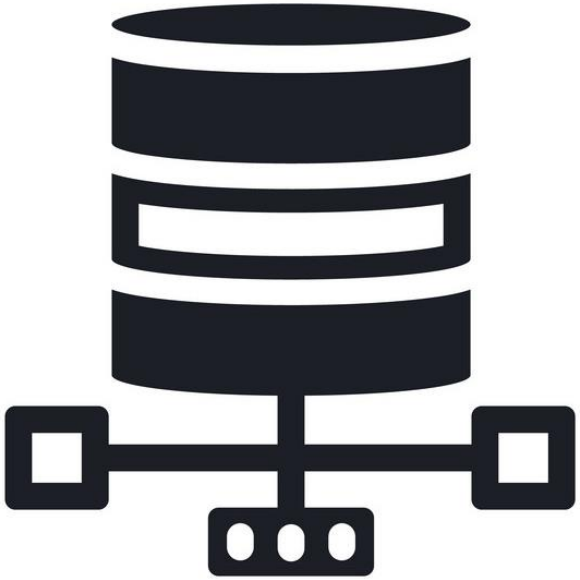
# Introduction to database and relational model



# General scheme of presentation

- What is a database and what is a DBMS.
- Different database models:
  - Hierarchical
  - Network
  - Relational
  - Object
- The relational databases
  - Fundamental concepts.
  - Different activities
  - Entity & relations models

# What is a database and what is a DBMS

- A database can be viewed as
  - On or more files
  - A set of structured data
- The database is managed by a DBMS. In most cases it‘s a server (exception: Ms-Access).
- A DBMS can manage one or more databases.
- It is possible to create links between databases.

# DBMS responsabilities

- The responsabilities of a DBMS are:
  - To manage the data and the definitions of the data structures (meta data).
  - To manage the security.
  - To manage the data integrity.
  - To give access to client applications.
  - To manage isolation between transactions.
  - ...

# Databases models

- Different models exist :

1. Hierarchical : nodes of data (set of fields/value) with parent-child relations forming a hierachical tree : a child may have only one parent
2. Network : nodes of data with relations between any nodes : it forms a network : a child may have many parents. In hierachical and network databases to retrieve a node you have to navigate through relations.
3. Relational : tables of data. A table is a set of records having the same structure and the same meaning (entities of the same type). A record is composed of fields; each field has a value. A one to one or one to many relation is modelized as a data field.
4. Object/Relational Model : extension to the relational model to work with objects.

...

# Relational model

- Values are atomic (we can‘t access only to a part of a value)
- The sequence of rows is insignificant
- In the different rows of the same table, the column values have the same type (the type is defined for the column)
- The sequence of columns is insignificant
- On each table you have to define a primary key (on a single column or on many). The primary key identifies the record. Values in primary key should be unique. Values in column participating to a primary key can‘t be null.
- On each table you may define indexes (on a single column or on many). Searches with creteria related to indexes are more efficient.

# Relational data bases – fundamental concepts

- Data stored in tables.
- Tables formed of rows and columns.
- Primary keys.
- Surrogate.
- Foreign keys.
- Integrity constraints.
-

# Database objects

- Schemas : collection of tables, indexes and views
- Tables : storage structure
- Views : stored select SQL
- Indexes : definition of indexation

# Primary key, surrogate key

- A primary key is the field that will identify each record in a table.
- A surrogate key is an artificial column added to a relation to serve as a primary key:
  - Often supplied by the DBMS (usage of a sequence)
  - Short, numeric and never changes – an ideal primary key!
  - Has technical values that are meaningless to users
  - Normally hidden in forms and reports

# Surrogate key, foreign keys

- You will use a surrogate key either for optimization reasons (less data, quick access) or when you have no “natural” key.
- A foreign key in a table is an identifier of a record of another table (in the table X, the foreign key on the table Y contains values of the primary key of the table Y). In other words, a foreign key is the primary key of one relation that is placed in another relation to form a link between the relations

# Referential integrity constraint

- A referential integrity constraint is a statement that limits the values of the foreign key to those already existing as primary key values in the corresponding relation

# Activities related to the usage of relational databases.

- Design : data modeling, data definition (meta-data) with SQL or with a tool
- Usage : data manipulation (SQL insert, update, delete) and retrieval (SQL select).
- Administration : security management, performance management, data integrity.

- Such activities are not always allocated to different people.

# Data modeling - Entity-relationship model

- The entity & relationship model is a way to represent structures and links that can be stored in a relational database. It is a tool for conceptualisation; it is used mainly during the analysis stage.
- An entity set is a group of entities having the same type (= a table). The definition of this type is part of the definition of the entity set.
- An entity is a flat structure (set of fields) holding the characteristics of a concrete thing (for examples a person, a training session) or of an abstract thing (for examples a knowledge, an objective). (= a table row)
- A relation defines the possibility to create links between two or more entities.
- An entity-relationship model can be represented by textual expressions or by graphs.
- To transform an entity-relationship model into a database model, entities are mapped to tables, relations are mapped as supplementary fields of entities tables or as separated tables.

# Entity-relation graphs

- Main represented elements are:
  - Entities sets
  - Attributes
  - Relations between entity sets
  - Cardinality of such relations.

# Relations cardinality

- Cardinality means “count,” and is expressed as a number.
- Maximum cardinality is the maximum number of entity instances that can participate in a relationship.
- Minimum cardinality is the minimum number of entity instances that must participate in a relationship.
- There are three types of maximum cardinality:
  - One-to-One [1:1]
  - One-to-Many [1:N]
  - Many-to-Many [N:M]

# ONE-TO-ONE Relationship

Example: AUTOMOBILE and REGISTRATION

| VIN_NUM | MAKE | MODEL | YEAR |
|---|---|---|---|
| | | | |

| REG_NUM | ADRESS | STATUS |
|---|---|---|
| | | |

May become

| VIN_UM | MAKE | MODEL | YEAR | REG_NUM | ADDRESS | STATUS |
|---|---|---|---|---|---|---|
| | | | | | | |

or

| VIN_NUM | MAKE | MODEL | YEAR | REG_NUM |
|---|---|---|---|---|
| | | | | |

| REG_NUM | ADRESS | STATUS |
|---|---|---|
| | | |

or

| MAKE | MODEL | YEAR | VIN_NUM |
|---|---|---|---|
| | | | |

| VIN_NUM | REG_NUM | ADRESS | STATUS |
|---|---|---|---|
| | | | |

# ONE-TO-MANY Relationship

Example: EMPLOYEE and DEPARTMENT (one department, many employees, one employee, only one department)

| EMP_NUM | NAME | GRADE |
|---|---|---|
| | | |

| DEP_NUM | NAME | ADRESS |
|---|---|---|
| | | |

becomes

| EMP_NUM | NAME | GRADE | DEP_NUM |
|---|---|---|---|
| | | | |

| DEP_NUM | NAME | ADRESS |
|---|---|---|
| | | |

# MANY-TO-MANY Relationship

Example: STUDENT and COURSE (many students in one course, many courses, per one student)

| STUD_ID | NAME | YEAR |
|---|---|---|
| | | |

| COURSE_ID | NAME | LEVEL |
|---|---|---|
| | | |

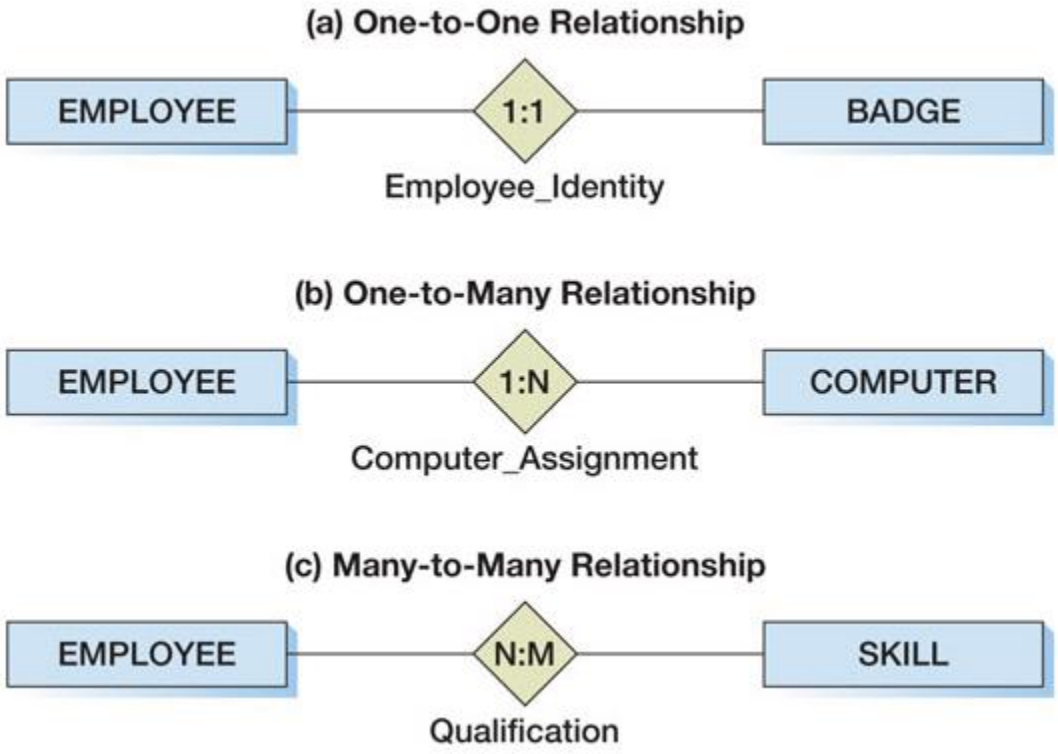
becomes

| NAME | YEAR | STUD_ID |
|---|---|---|
| | | |

| COURSE_ID | NAME | LEVEL |
|---|---|---|
| | | |

| STUD_ID | COURSE_ID |
|---|---|
| | |

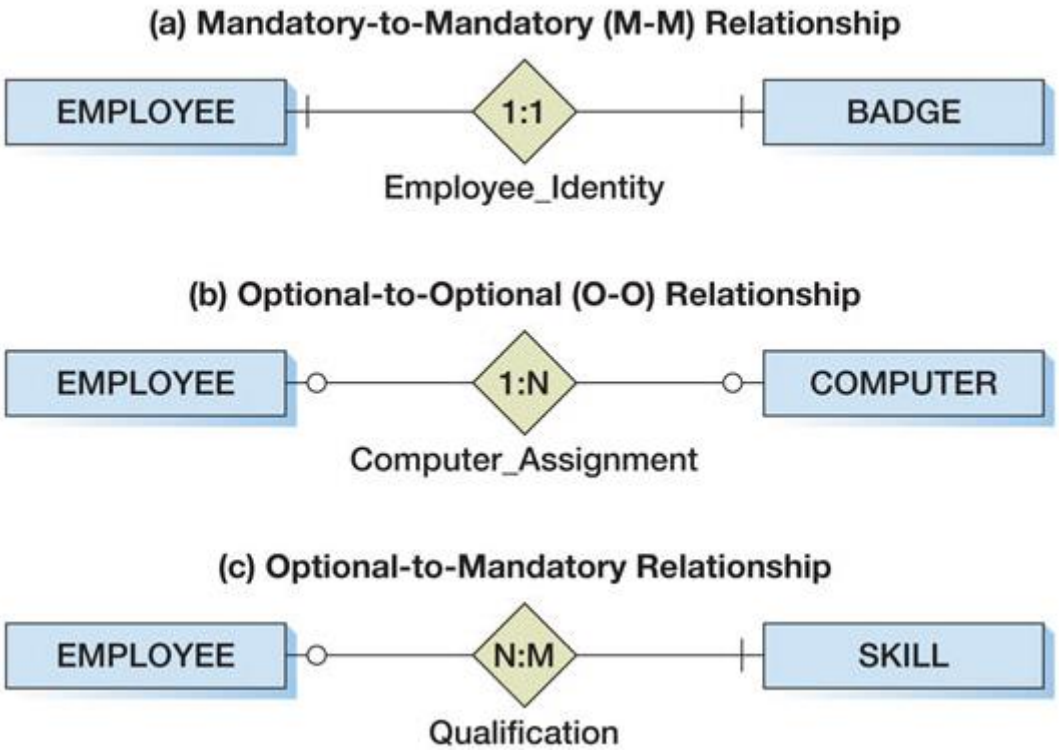
# Relations – graphical representation of max cardinality



# Relations – min cardinality

- Minimums are generally stated as either zero or one:
  - IF **zero [0]** THEN participation in the relationship by the entity is **optional**, and **no** entity instance must participate in the relationship.
  - IF **one [1]** THEN participation in the relationship by the entity is **mandatory**, and **at least one** entity instance must participate in the relationship.

# Relations – graphical representation of min cardinality



# Data Modeling – Crow's Foot representation

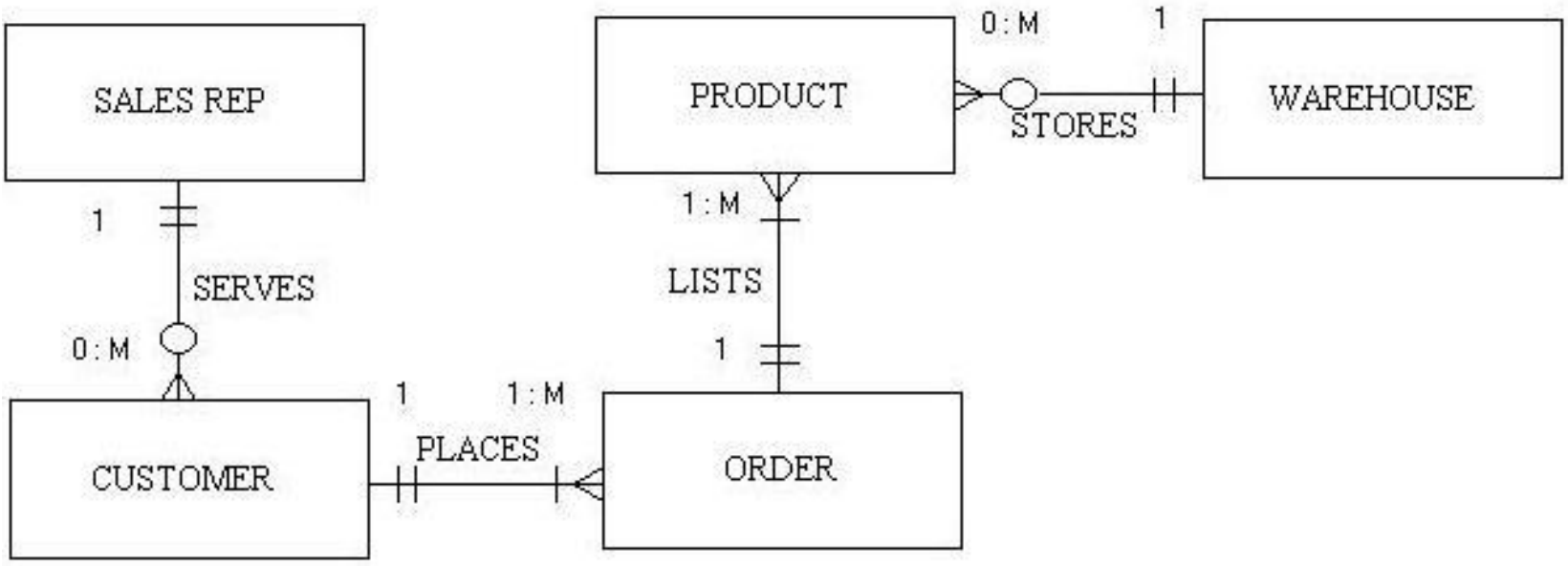


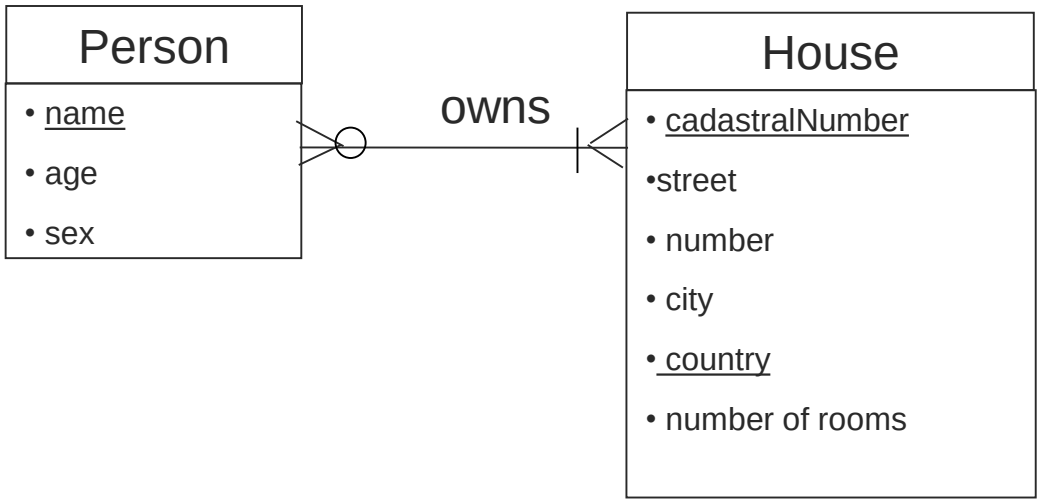

**Figure 1. Entity-Relationship Diagram**

* 1 INSTANCE OF A SALES REP SERVES 1 TO MANY CUSTOMERS
* 1 INSTANCE OF A CUSTOMER PLACES 1 TO MANY ORDERS
* 1 INSTANCE OF AN ORDER LISTS 1 TO MANY PRODUCTS
* 1 INSTANCE OF A WAREHOUSE STORES 0 TO MANY PRODUCTS

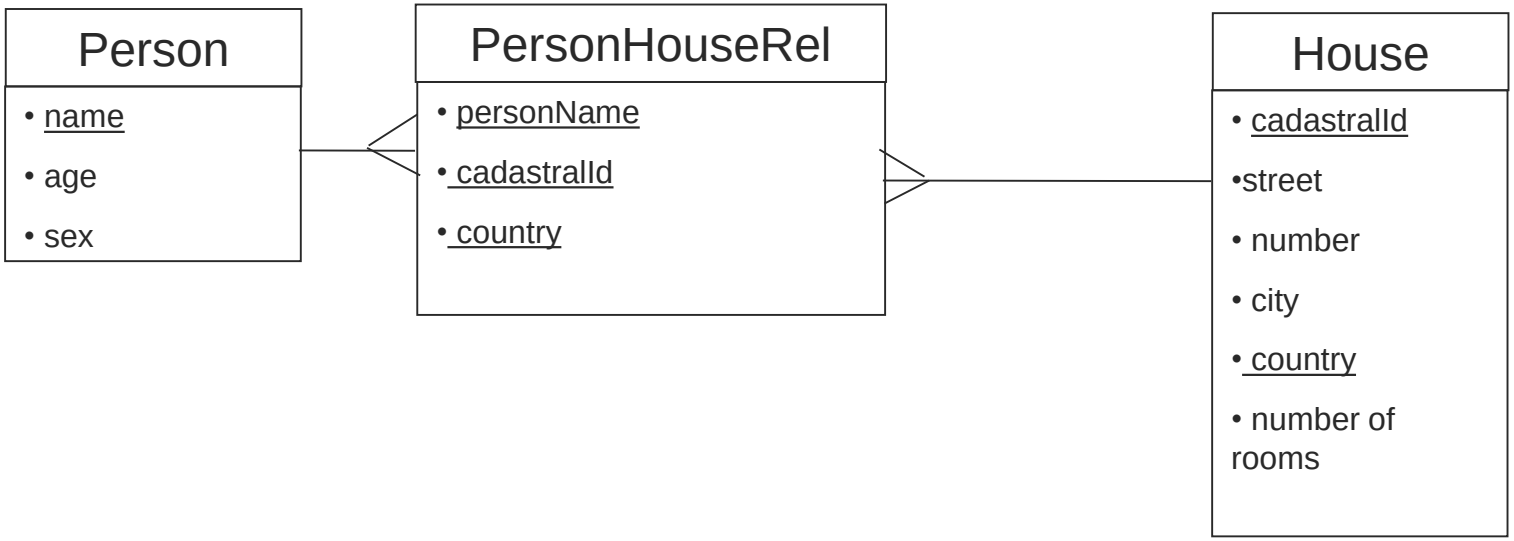
# Data modeling - Logical vs Physical Model

- The logical model is created as support of the design phase. Normally, the designer will work on the logical model to obtain a normalized form (the normalization process is explained here after).
- The physical model directly represents what will be created (tables and relations) in the database.
- The main difference are:
  - In the physical model all “many to many” relations are represented via an intermediary table.
  - In the logical model, foreign keys are not shown.
- Physical considerations may cause the physical data model to be quite different from the logical data model (de-normalization).

# Example of a logical model



# Example of a physical model



# Normalization forms

- Normalization = respect of guide lines.  Enforce the data consistence (no redundant data).
- 1 NF:  each field has a single value, we can't have a variable number of fields in two records of the same table.
- 2 NF: 1NF + a non-key field must give an information (a fact) related to the key, as the whole key, and nothing but the key.
- 3 NF: 2NF + a non-key field can not be an information related to another non-key field
- 4 NF: 3NF + a table should not contain two multi-valued facts about an entity.
- …

# 1NF

- Each field has a single value, we can’t have a variable number of fields in two records of the same table.
- Bad example:

| PersonName | Age | Children |
|---|---|---|
| Gaston | 65 | Benoit,Françoise |
| André | 47 | Alice, Pascal, Eloïse |

# 1NF

- Each field has a single value, we can't have a variable number of fields in two records of the same table.
- Bad example:

| Person Name | Age | Child1 | Child2 | Child3 | Child4 | Child5 |
|---|---|---|---|---|---|---|
| Gaston | 65 | Benoît | Françoise | Null | Null | Null |
| André | 47 | Alice | Pascal | Eloïse | Null | Null |

# 1NF

- Each field has a single value, we can't have a variable number of fields in two records of the same table.
- A possible solution:

table1

| Person Name | age |
|---|---|
| Gaston | 65 |
| André | 47 |

table2

| FatherName | Child |
|---|---|
| Gaston | Benoît |
| Gaston | Françoise |
| André | Alice |
| André | Pascal |
| André | Eloïse |

# 2NF

- 2 NF: A non-key field must give an information (a fact) related to the key, as the whole key, and nothing but the key.
- Bad example:

Headquarters

| Company | Country | NbEmpl | Currency |
|---|---|---|---|
| CW | BE | 450 | Euro |
| CW | GB | 50 | GBP |
| CW | LU | 60 | Euro |

# 2NF

- 2 NF: A non-key field must give an information (a fact) related to the key, as the whole key, and nothing but the key.
- A possible solution:

Headquarters

| Company | Country | NbEmpl |
|---|---|---|
| CW | BE | 450 |
| CW | GB | 50 |
| CW | LU | 60 |

Countries

| Country | Currency |
|---|---|
| BE | Euro |
| GB | GBP |
| LU | Euro |

# 3NF

- A non-key field can not be an information related to another non-key field
- Bad example:

Countries

| Country | Currency | Roundup |
|---|---|---|
| BE | Euro | 0.01 |
| GB | GBP | 0.01 |
| LU | Euro | 0.01 |

# 3NF

- A non-key field can not be an information related to another non-key field
- A possible solution:

Countries

| Country | Currency |
|---|---|
| BE | Euro |
| GB | GBP |
| LU | Euro |

Currencies

| Currency | Roundup |
|---|---|
| Euro | 0.01 |
| GBP | 0.01 |

# 4NF

- A table should not contain two multi-valued facts about an entity.
- Bad example:

| EmployeeId | skill | Language |
|---|---|---|
| awe | C | FR |
| awe | Java | EN |
| awe | SQL | Null |
| xyz | Accounting | EN |

# 4NF

- A table should not contain two multi-valued facts about an entity.
- A possible solution:

| EmployeeId | skill |
|---|---|
| awe | C |
| awe | Java |
| awe | SQL |
| xyz | Accounting |

| EmployeeId | Language |
|---|---|
| awe | FR |
| awe | EN |
| awe | Null |
| xyz | EN |

# Thanks for your attention!