Database Systems I

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Content

- Introduction
- Conceptual model
  - Tools for conceptual modeling
  - E-R model
  - UML model

Information sysems

- An information system (IS) is a special type of a software work
- When developing an IS, we use the recommended software development techniques
- However, we focus only on a part of an IS development that concerns **databases** in this subject

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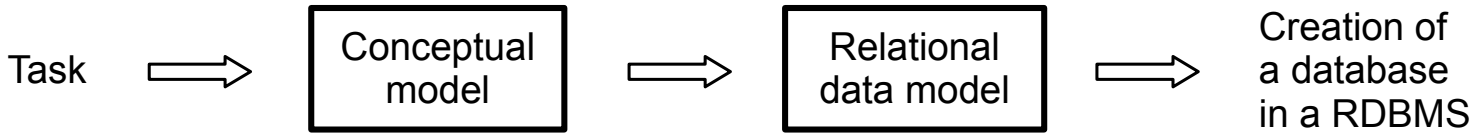
Data analysis

- Three steps for a database development:
  - **Task** - written specification of the task
  - **Conceptual modeling** (conceptual model) - a logical description of a database
  - **Database scheme design** (relational data model) - a description of a database defined for a conrete database system
  - **Physical design** - a concrete implementation of data files (CREATE TABLE . . . , CREATE INDEX . . .)



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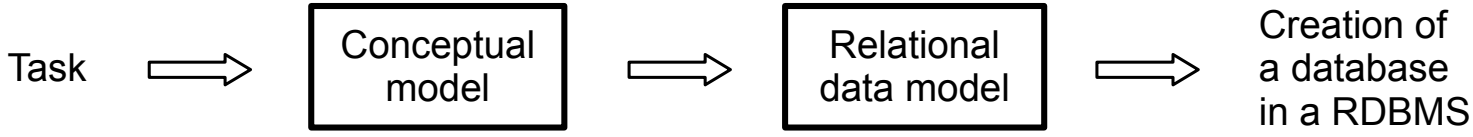

Task

- Task formulate the requirements
- Features:
  - Description in a text form
  - Ambiguous, incomplete, inaccurate
  - Understandable to both the client and the developer

Task Specification

Task specification constructively answers the following questions:

- WHY? The motivation behind the IS creation
- FOR WHAT? Problems solved by the IS
- WHO? Roles of users that will use the IS
- INPUTS? The entities that we want to store in our system
- OUTPUTS? The most important views
- FUNCTIONS? Non trivial functions

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WHO?

- Describe roles of users in the company that will be using your IS
- Those people have specific job/role in the company, describe it
- Do not write roles USER and ADMIN! ADMIN is not a role in a company!

Example - WHY?

- We need a room reservation system in our building
- There is no central authority and we often argue about the rooms between the colleagues
- Some colleagues even take personally if the room is not empty for their meeting

Example - FOR WHAT?

- The software will provide a simple way to organize reservations in a building
- The system will not only provide a way to reserve a meeting room, but it will also offer a possibility to define a single authority for a meeting room
- The authority will have an authorization to cancel a reservation in that room and the software will implement a notification system as well that will send an email in such case

Example - WHO?

- Company employee – a person that work in a company and have to organize a meeting time to time. This is the person that will have a possibility to create a reservation.
- Company manager – a person that manage a larger group of people and need a meeting room for them and for himself quite often.
- Codebook keeper – a person that will keep the codebooks in the database up-to-date

Example - INPUTS?

- **Person** information such as name, email, office, phone and flag indicating whether it is a office manager or not (Company employee, Company manager).
- For each **room** we store its building, floor, room number and room authority (Codebook keeper).
- Information about a **reservation** such as reservation date, meeting interval, room and person who created the reservation (Company employee, Company manager).
- Each person can create many reservations.

Example - OUTPUTS?

- List of an employee future reservations that are sorted according to the meeting time ascending order. Employee may also list the history of his reservations according to a specified time interval. (Company employee)
- List of a future room reservations. The system should offer also a week schedule for a room. (Company employee, Company manager)
- List of free rooms for a specific time. (Company employee)

Example - FUNCTIONS?

- Possibility to create a reservation in a meeting room even though there are already reservations (only for a company manager). In such a case, the system will propose an empty meeting room in a similar time for each overlapping reservation.
- The system will notify by email each user whose reservation was shifted.

Example - HISTORY

- If a reservation is moved by somebody else than the owner, then we need to keep the original reservation in the system. In other words, we need to track back the history of reservation changes made by a company manager.

The Project Topic

When selecting the topic of the project consider the following:

- The topic have to be familiar to you
  - Do not select bank accounts or bank loans if you never worked in a bank
  - Do not select food delivery if you have no experience with it
- It should not be easily replaceable by a content management system
  - Database of battles and persons in a World War II
  - Database of space objects

Conceptual Modeling

- is a process of a development of a system description that is used to design and implement a database application
- is independent of database
- defines restrictions put on data

Linear Notation & Basic Concepts

- Linear notation:

  `Student(stID, name, birth_year)`

  `Subject(suID, name, study_year)`

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- **Entity type**
- **Attribute**
- **Key**

- **Entity** – object of a reality (one instance of entity type)

Relationship

- **Relationship** - describes a relationship among entity types
  - Linear notation:
    `RELATIONSHIP(EntityType`$_1$`, ..., EntityType`$_n$`)`
  - Two or more entity types can be in a relationship
- **Relationship with attributes** - a relationship containing also attributes specifying properties of the relationship
- *Example of a relationship (the relationship Studies)*

```
STUDIES(Student, Subject)
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- *Example of a relationship with attributes (the relationship Studies)*

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STUDIES(Student, Subject, gained_points)
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Relationship, Example 1

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Relationship, Example 1

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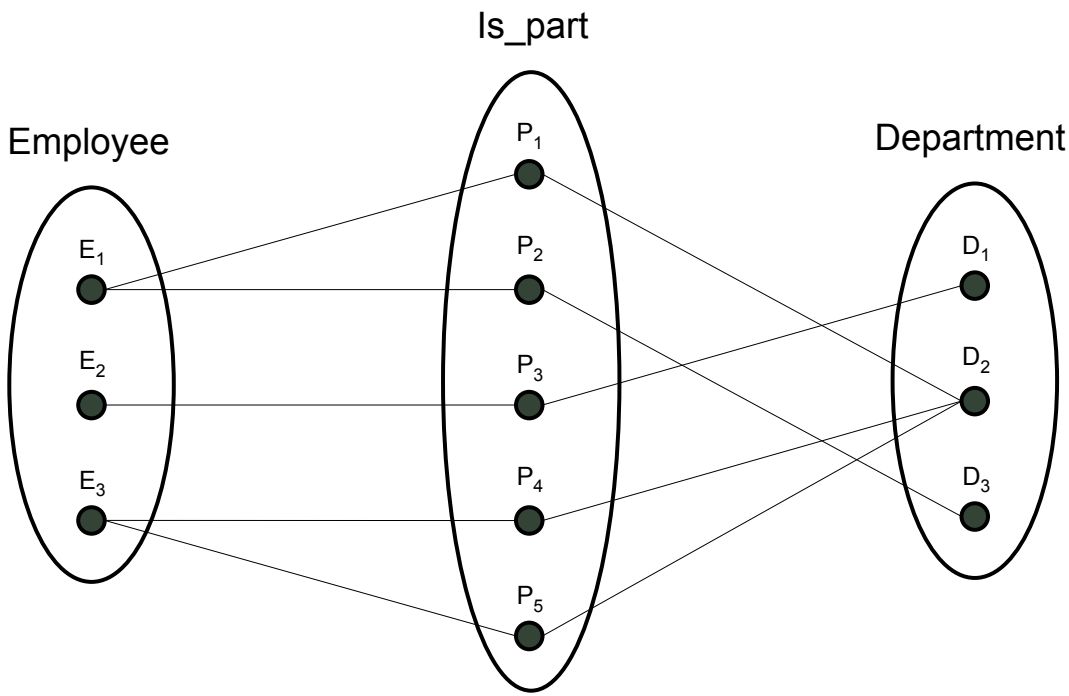
  `COORDINATE(Student, Student)`

Cardinality of a Relationship

- We distinguish relationships according to number of entities entering a relationship
- A relationship between two entity types (a so-called binary relationship) can be of the following types:
  - 1:1, 1:N, M:N
- *Consider a company with the entity types Department and Employee.*
  - Cardinality 1:1 - an employee can be a chief only of one department
  - Cardinality 1:N - an employee can belong only to one department
  - Cardinality M:N - an employee can belong to several departments

Cardinality

- In order to determine cardinality, it can be useful to draw the following diagram:



Mandatory/Obligatory Relationships

- Some entities has to have a relationship and some does not:
  - Mandatory relationship - each entity has to have a relationship
  - Obligatory relationship - there can be entities without relationship

- Linear notation:

$$\texttt{RELATIONSHIP(EntityType}_1\texttt{:(min,max),}$$
$$\texttt{EntityType}_2\texttt{:(min,max))}$$

Relationships, Example 2

- *A teacher does not have to teach, but a subject has to have a teacher. A teacher is teaching many subjects and a subject can be taught by many teachers.*

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- *A teacher does not have to teach, but a subject has to have a teacher. A teacher is teaching many subjects and a subject can be taught by many teachers.*

```
TEACH(Teacher:(0,M), Subject:(1,N))
```

Constraints

- **Constraints** provide additional information for conceptual model
- They are invariants of the database which have to be always satisfied
- Their typically concern:
  - an attribute value (e.g., the format of email)
  - relationship among entities (e.g., a department has to have its chief)

E-R diagram (ERD)

- Graphic representation of conceptual model
- Unfortunately, there is no standard for it, therefore, one can come across many different notations of ERDs
- Let us mention just of them:
  - Chen's notation
  - Crow's foot notation
    - Oracle data modeler
    - Toad data modeler

Types of ERD

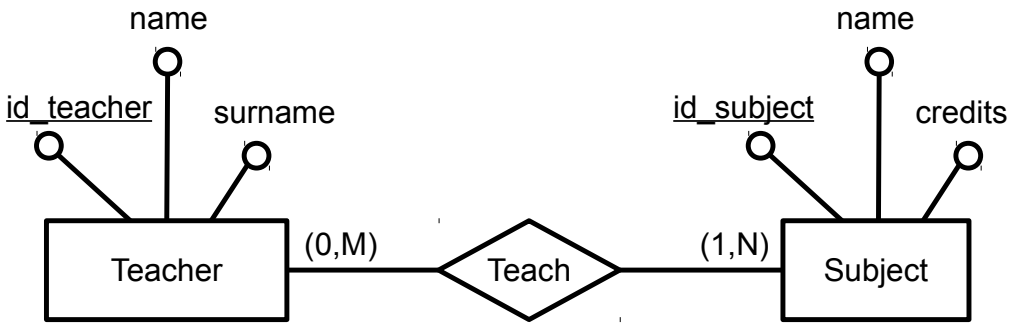

FIGURE: Chen's notation

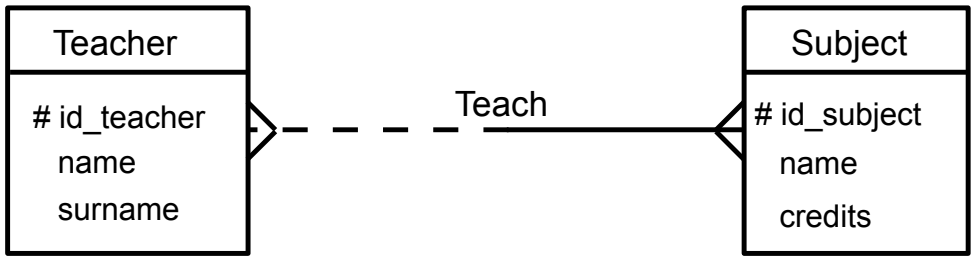

FIGURE: Crow's foot notation - Oracle

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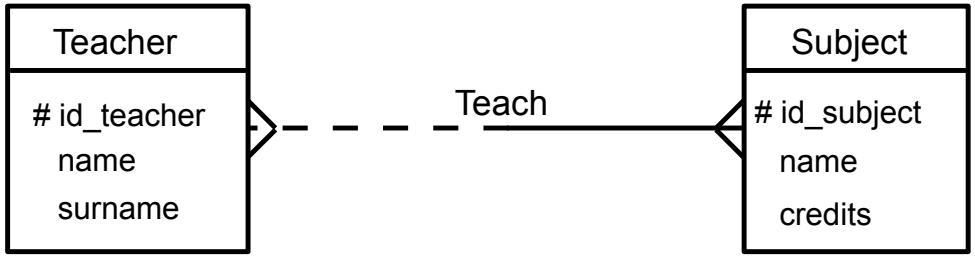

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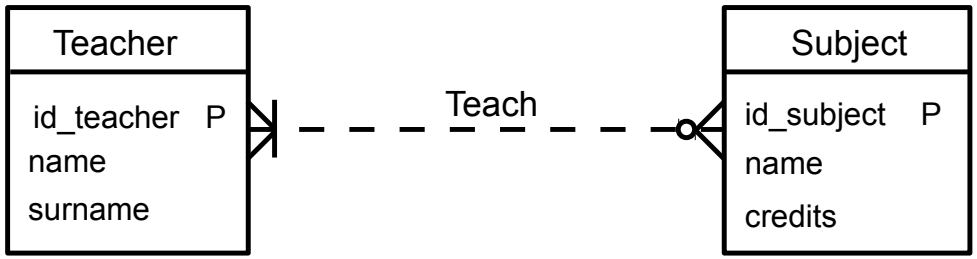


FIGURE: Crow's foot notation - Toad

Cardinality in ERD

- Cardinality is represented by a number or by crow's foot
- See previous slide

Mandatory/Obligatory relationships

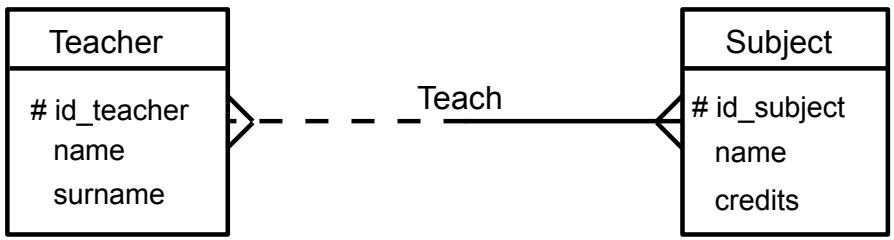
- It is solved by many different ways, but there are two basic categories:
  - Information is contained in pair (min, max), which determine the cardinality as well
  - We use some graphical symbol that determine mandatory and obligatory relationships

Mandatory/Obligatory relationships - (min, max)

- It is used in UML
- Pair `(min, max)` determine maximum and minimum number of entities that are in the relationship
- Having the `TEACH` rel. between `Subject` and `Teacher`
  - `Subject:(0,N)` - Teacher does not have to have a subject
  - `Subject:(1,N)` - Teacher has to have a subject
  - `Subject:(0,1)` - Teacher does not have to have a subject
  - `Subject:(1,1)` - Teacher has to have exactly one subject

M/O relationships - graphical symbol

- *Subject has to have at least one teacher and teacher does not have to teach anything*



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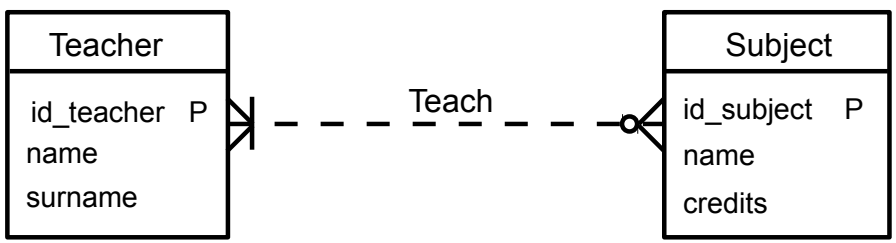

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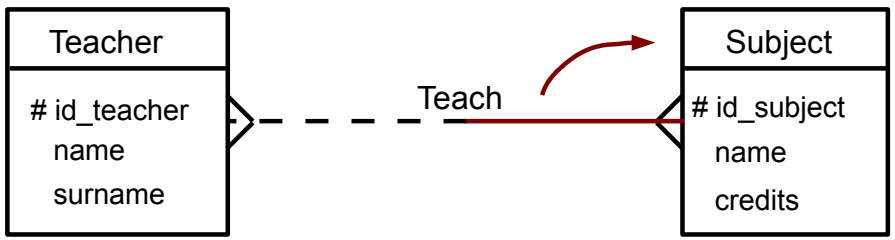

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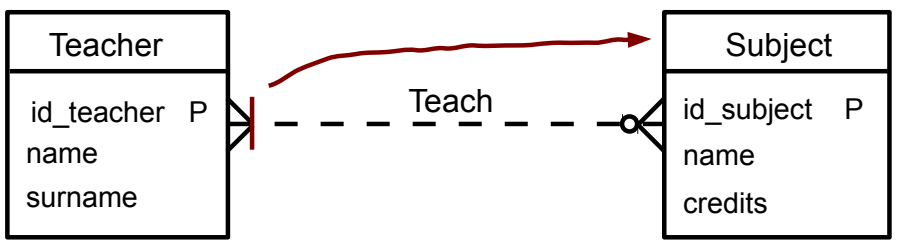

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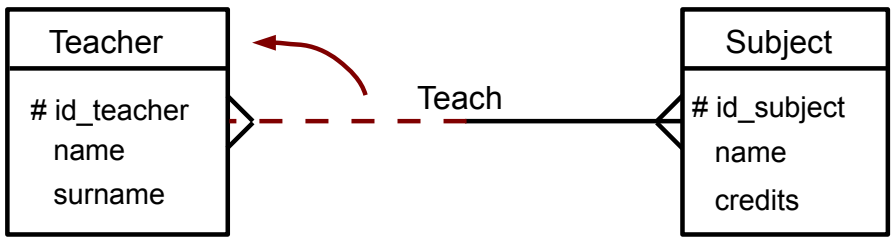

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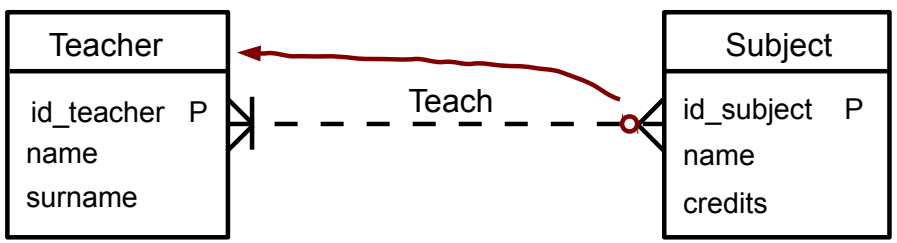

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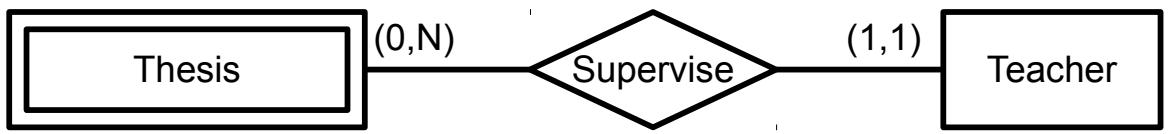
Weak entity types

- Sometimes a key is formed by attributes belonging to another entity types
- The entity make sense only with respect to a different entity
- Then we speak about a so-called *weak entity type*

- *Diploma thesis is determined by both its title and its supervisor.*



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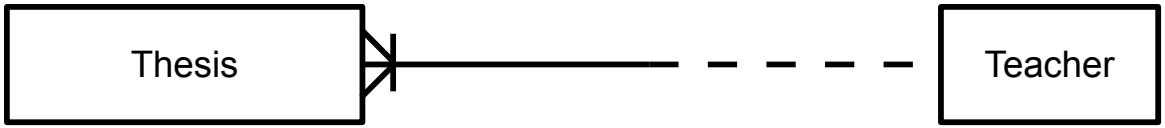
Weak entity types - Oracle, TOAD



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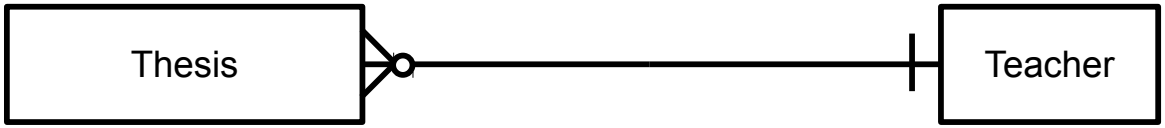

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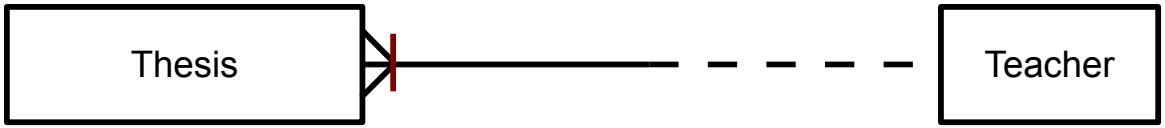

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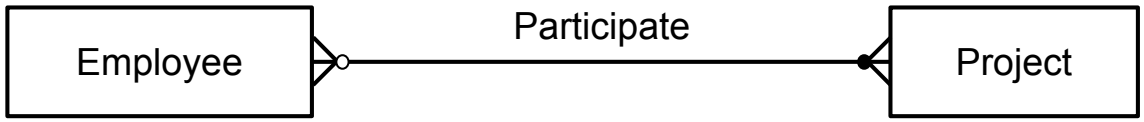
Decomposition of a relationship



- In the relational scheme, we decompose the relationship M : N by using a table

Description of Data model in Project

- Table containing a more detailed description of attributes
- Every table corresponds to a single entity type

User

	Data type	Lenght	Key	Null	Index	AC	Meaning
login	varchar	10	Y	N	Y		user's login
fname	varchar	20	N	N	N		user's first name
lname	varchar	20	N	N	Y		user's last name
phone	number	12	N	Y	N		phone number
type	varchar	10	N	N	N	1	user's cathegory
last_visit	Timestamp		N	Y	N		date of user's last login to the IS

1: data type must be one of these: admin, bidder, or user

UML

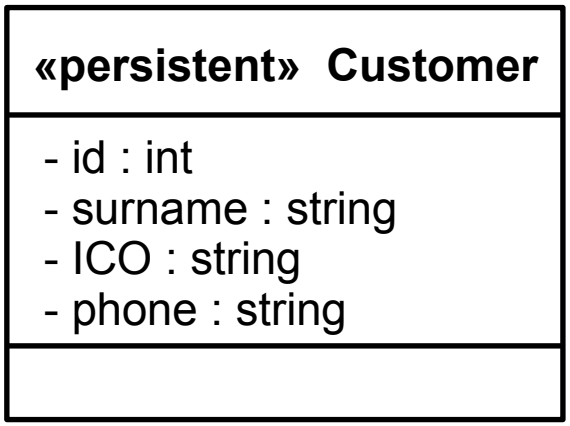
- UML is another tool wich enables us to design conceptual model of a system
- It represents an alternative to E-R diagrams (ERDs)
- It is a visual, object-oriented language modeling structural and dynamic aspects of a software work
- Unlike ERD, UML is a collection of modeling techniques that are applied to various aspects of software development
- Every UML technique provides different static or dynamic perspective of an application (a so-called model)

UML versus ERD

UML	*ERD*
class	entity type
object	entity
attribute	attribute
association	relationship

Class

- describes a structure and a behavior of an object representing an instance of the class
- Three parts: class name, attributes, and methods



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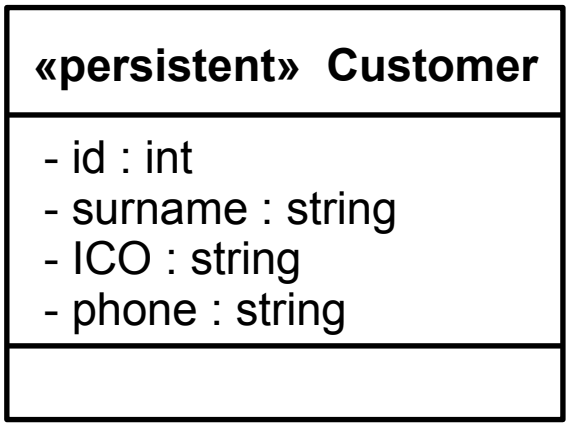
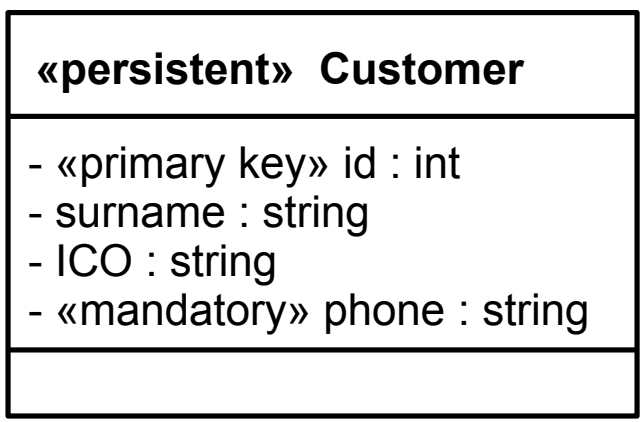


Stereotypes

- extend the description (of attributes and class)
- are written between the symbols ≪ ≫
- The notation ≪ Persistent ≫ means that the class (attribute) will be mapped to the database, i.e., to the relational database scheme
- Furthermore, we can specify a primary key, mandatory attributes, etc.



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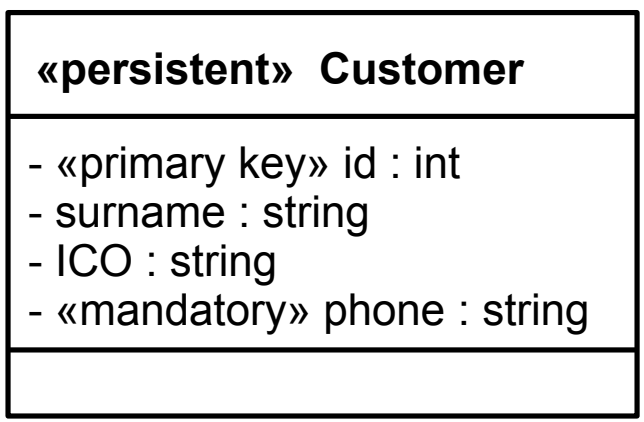

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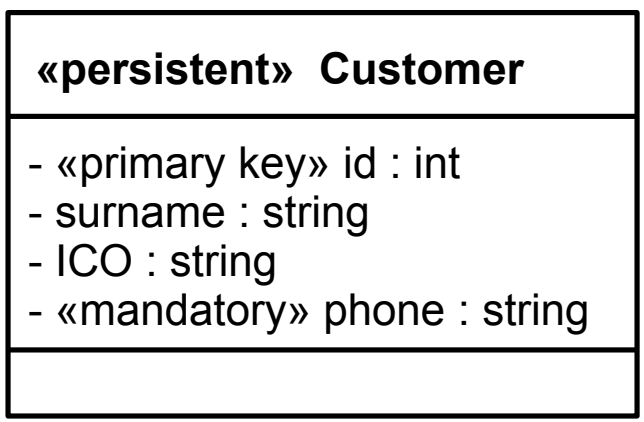

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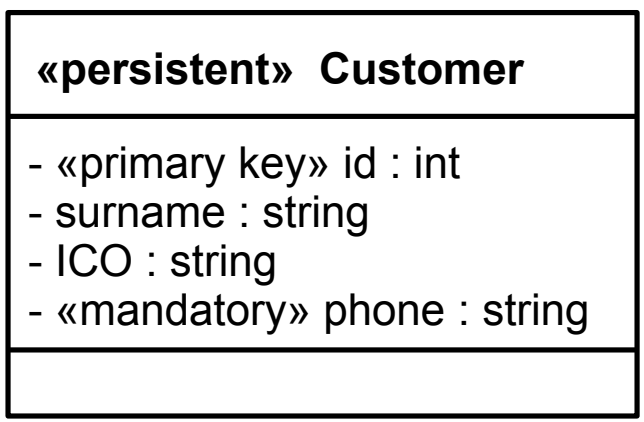
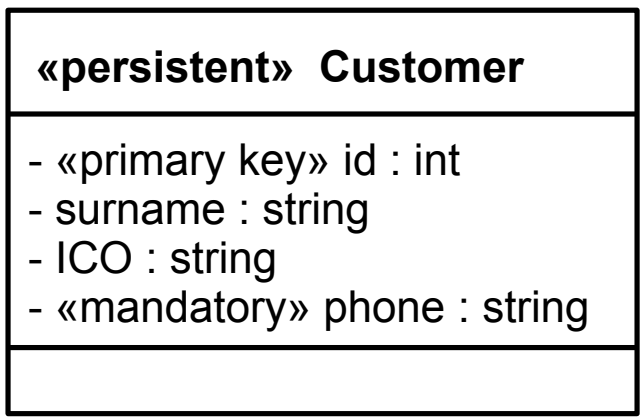


Syntax of attributes

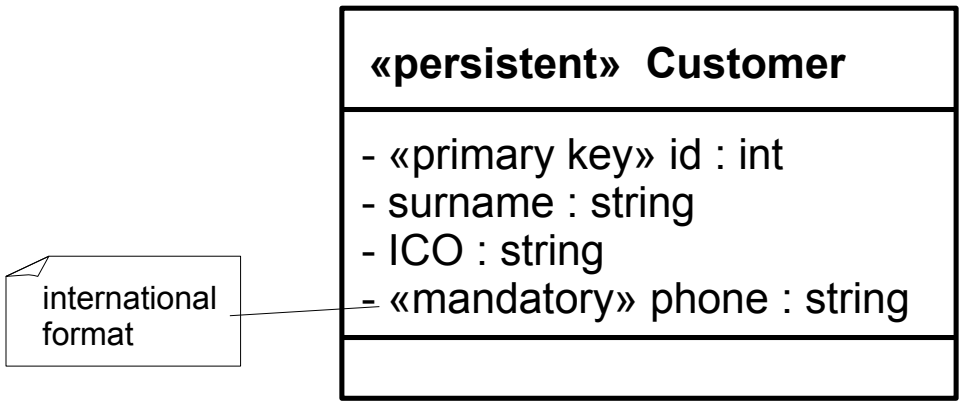
`[visibility] [≪stereotype≫] attribute : [type]`

- `visibility` - gains the value
  - + for a public attribute
  - # for a protected attribute
  - – for a private attribute
- `≪stereotype≫` - adds more semantics to an attribute
- `attribute` - name of an attribute

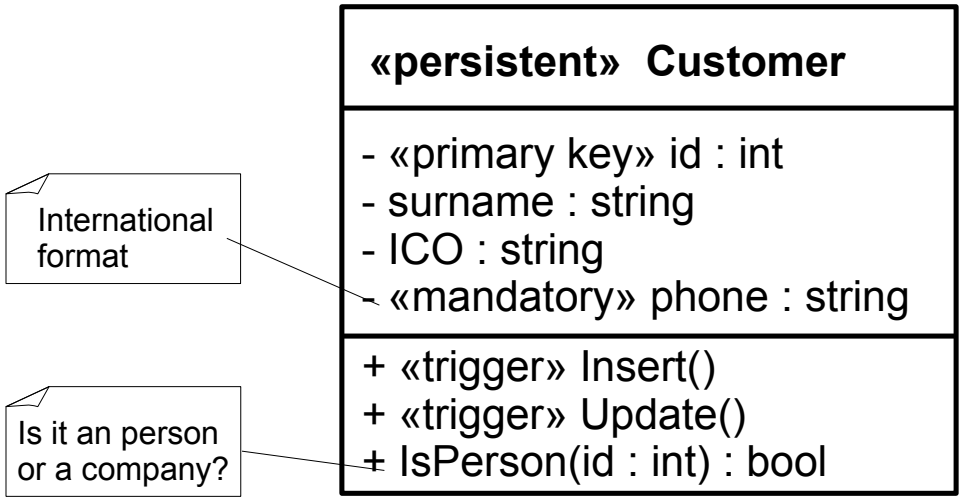


Example: attributes and notes

Notes are used to specify an attribute in more detail, e.g., for further specification of format of the telephone number



Example: Operations [1/2]



- The stereotype `trigger` indicates that a method is a trigger (i.e., a code which runs automatically during a DML operation)
- The method `IsPerson` returns an information, whether the customer is a person or a company; we should also decide, whether the method will be a stored procedure or whether it will be a part of the application

Association

- is an equivalent to a relationship in ERD
- Again, the cardinality can be 1:1, 1:N, M:N
- When describing an association, we mention: name, role, cardinality, and whether the association is mandatory or not
- By an arrow we can determine the direction of an association

Conceptual modeling summary

- Linear notation of entity types and linear notation of relationships among entity types
- Graphic illustration of data model:
  - E-R diagram or UML diagram
  - transformed diagram for database scheme (see the next lecture)
- Data model
- List of constraints

Software for conceptual modeling

- Microsoft SQL Server 2008 Management Studio
- Oracle SQL Developer Data Modeler
- MySQL Workbench, (previously MySQL GUI Tools)
- Toad Data Modeler
- And a lot more:
  `http://www.databaseanswers.org/modelling_tools.htm`

References

- R. Elmasri, S. Navathe. Fundamentals of Database Systems, Addison Wesley, ISBN 0-321-36957-2, 2010.
- UDBS web pages at `http://dbedu.cs.vsb.cz`