Data Modelling and Databases - Week 4 (Lectures)

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Recap

Learning Resources

Following are three really good Katacoda Tutorials:

1. https://www.katacoda.com/zhangce/scenarios/sql1
2. https://katacoda.com/dkoutsou/scenarios/sql-interactive-part-1
3. https://katacoda.com/dkoutsou/scenarios/sql-interactive-part-2

Entity-Relationship Model

Conceptual Modeling, Logical Modeling, and Physical Modeling

The process of implementing a real-world application includes modeling a DB. Modeling a DB goes through the following stages:

1. *Conceptual Modeling:* Capture the domain to be represented
2. *Logical Modeling:* Mapping the concepts to a concrete logical representation
3. *Physical Modeling:* Implementation in a concrete hardware

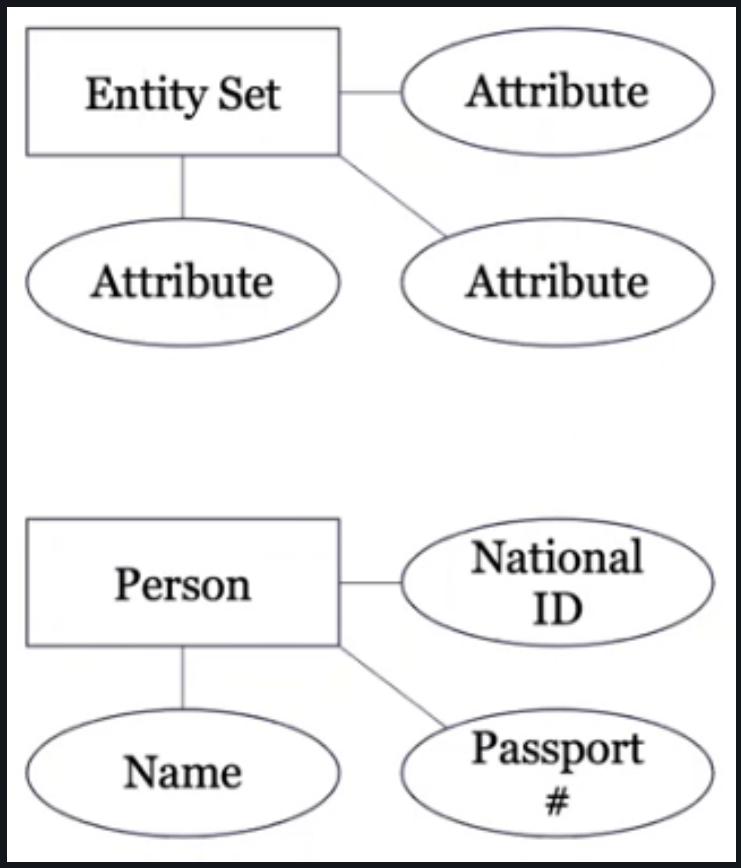
Conceptual Modeling using Entity-Relationship Model

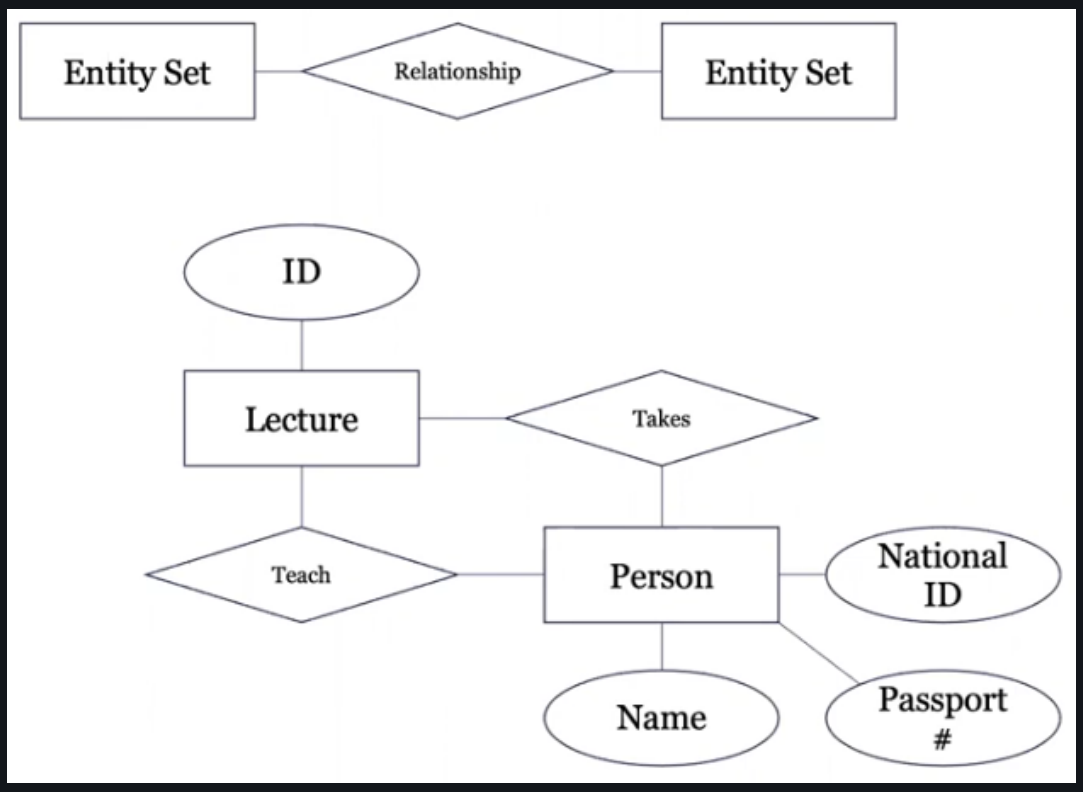
Basic Concept

An `Entity-Relationship Model` models an application in the following three element types:

- `Entity sets` : A set of similar entities, where an `entity` is defined as an object in the real world that is dishtinguishable from other objects. "*Similar*" means that entities in the same entity set share the same attributes (E.g. "Professor" is an entity set, "ProfA" is an entity).
- `Attributes` : E.g. ID and name of a professor.
- `Relationships` : Relationships are connections among two or more entity sets, e.g. relationship between professor and lecture.

An `ER-Diagram` is a graphical way of representing entities and the relationships among them.





`Primary keys` are underlined in an ER-Diagram.

Formal Semantics of ER-Diagram

An ER-Diagram is a constraint language, defining the set of *valid DB instances*.
All the values the DB can take is given by $\mathcal{D} = \mathcal{B} \cup \Delta$, where:

- $\mathcal{B}$: concrete values (Int, String, etc.)
- Δ : abstarct values (corresponding to an entity)

We can then furthermore define:

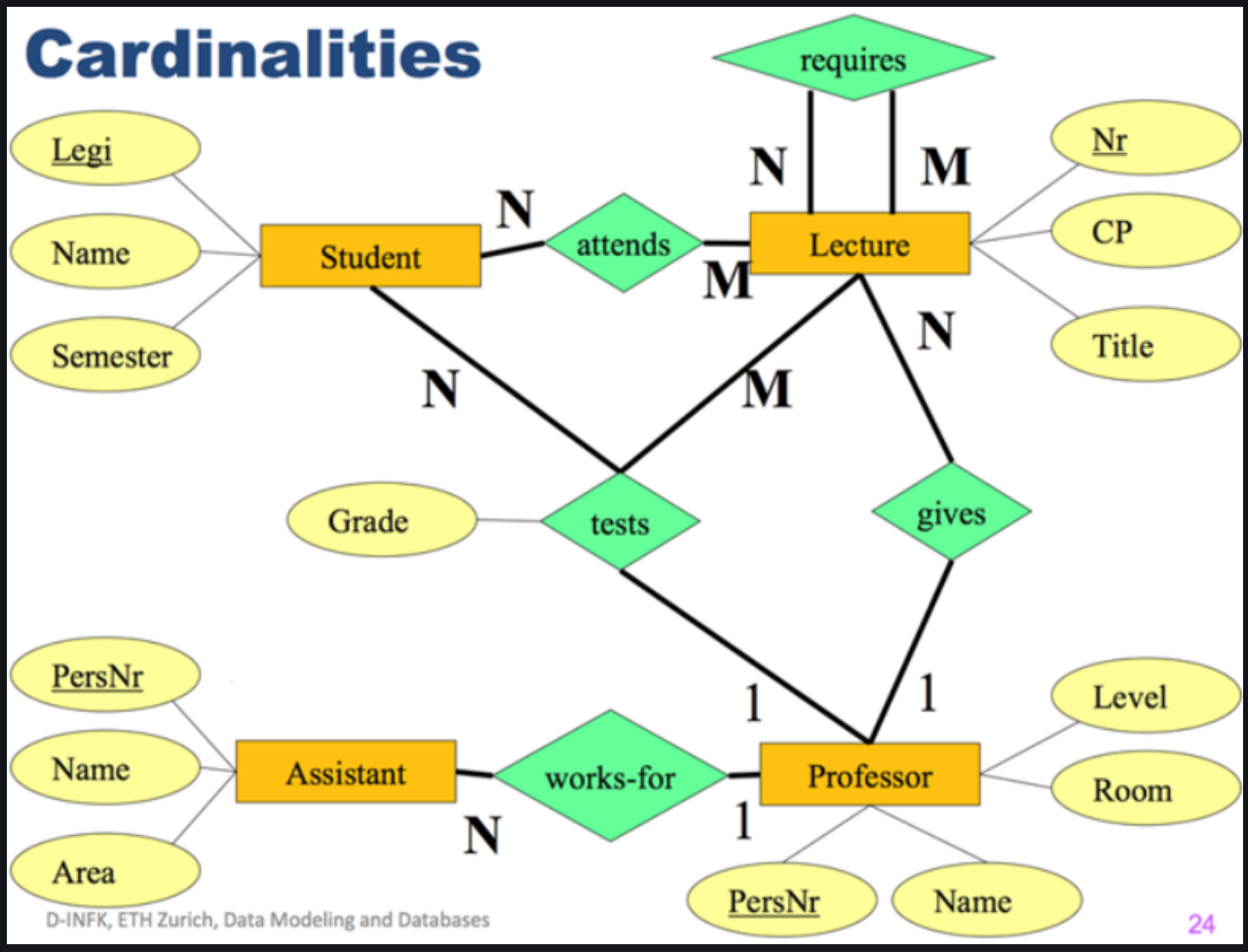
- Entity set E : 1-ary predicate $E(x)$, i.e. $E(x)$ is true if x is of entity type E
- Attribute A : binary predicate $A(x, y)$, i.e. $A(x, y)$ is true if x has attribute y
- n-ary relation R : n-ary predicate $R(x_1, \ldots, x_n)$, i.e. $R(x_1, \ldots, x_n)$ is true if $(x_1, \ldots, x_n)$ participate in R

Cardinality in ER-Diagrams

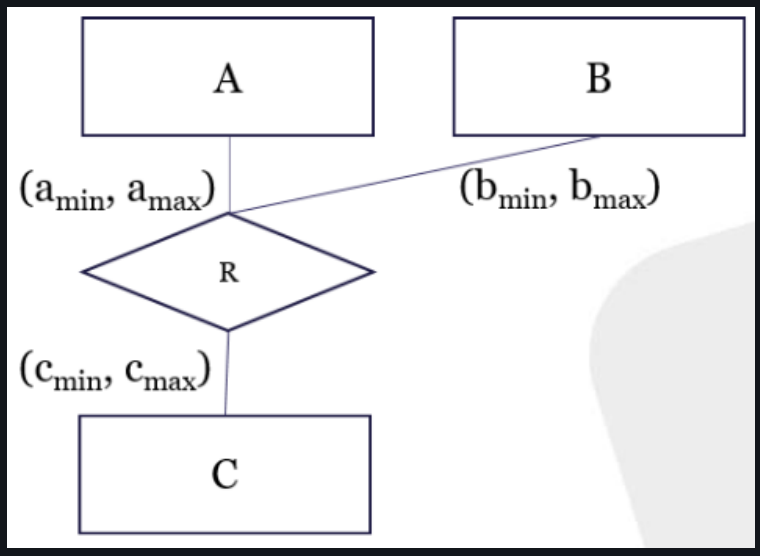
For relationships we distinguish between different types:

- 1-to-many
- 1-to-1
- many-to-many
- many-to-1

Example:



We can also have a more expressive notation, called `(min, max)-notation`:



This specifies the following constraints:

- $\forall x_A . A(x_A) \Rightarrow \exists^{\geq a_{min}, \leq a_{max}} x'_B, x'_C . R(x_A, x'_B, x'_C)$
- etc.

Weak Entities in ER-Diagrams

Some entity's existence relies on other entities. E.g., both buildings CAB and HG have a room with number F 1. So how can we uniquely identify those two rooms?

We therefore say that *Room* is a `weak entity` relying on *Building*. The key of *Room* would be *(Bld#, Room#)*.

Design Principles of ER-Diagrams

When designing ER-diagrams, one should follow the following rules:

- Attribute vs. Entity
  - Entity if the concept has more than one relationship
  - Attribute if the concept has only 1:1 relationship
- Partitioning of ER-Models
  - Most realistic models are larger than a page
  - Partition by domains (library, research, finances, etc.)
- Good vs Bad models
  - Do not model redundancy or tricks to improve performance
  - Less entities is better
  - Remember the `C4 rule`: *concise, correct, complete, comprehensive*

One might use https://erdplus.com/ to design simple ER-diagrams.

Logical Modeling

ER-Diagram to Relational Model

Principles

- Entities become relations
- Relationships become relations
- Entity sets become tables
- Attributes of entity sets become attributes of the table
- Merge relations with the same key

Note that when there is no cardinality constraints, a `relationship becomes a table`, containing the keys of all participating entity sets.