Unit 2: Entity-Relationship Model.

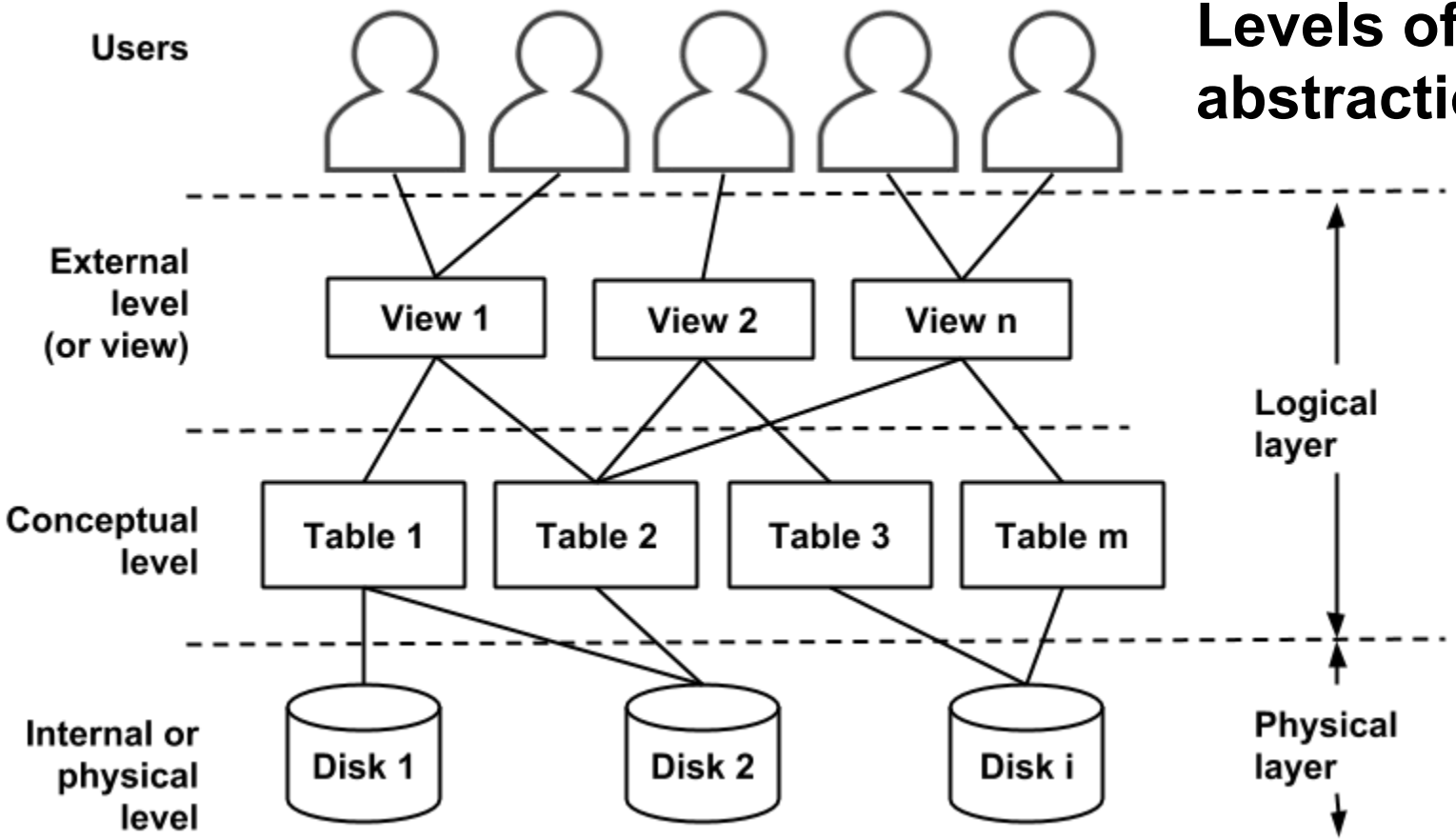
2022/2023

Contents

2.1. Introduction.

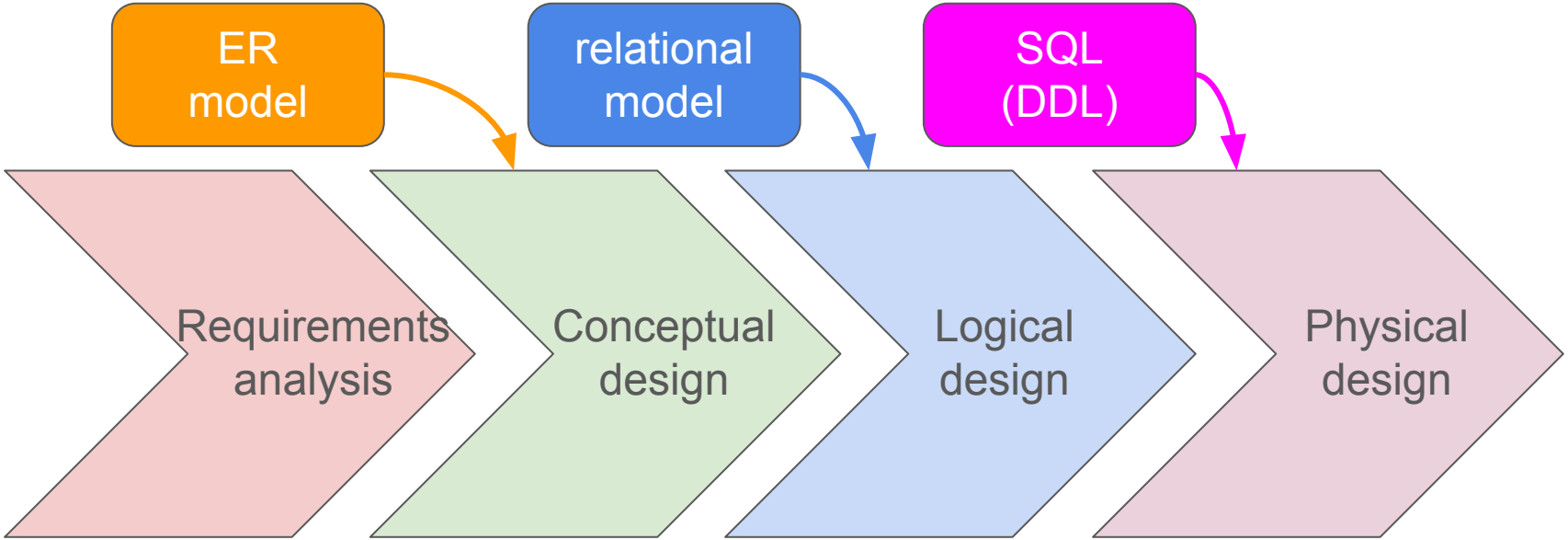
A **data model**…	A **data model**…	A **data model**…
…is the result of **modeling the data of a system**.	…describes the **data**, **relationships** between different data, **semantics** associated with data and **constraints of consistency.**	…is an essential way **to communicate with the Database Administrator** (DBA).
E.g.: The blueprint for the house made by an architect.		DBA is the one responsible to ensure the correct and efficient operation of the System DBs).

Levels of data abstraction



https://docs.oracle.com/cd/A84870_01/doc/server.816/a76994/physical.htm

2.1. Introduction.



2.1. Introduction.

ER data model…
…was developed to facilitate database design by allowing specification of an **enterprise schema that represents the overall logical structure of a database**.
…**describes graphically data addressed to users**.
…**does not intend to describe how data will be stored internally**.

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- The E-R Model was proposed by **Peter Chen** in **1976** to represent conceptually problems of the real world.

A data model, called the entity-relationship model, is proposed. This model incorporates some of the important semantic information about the real world. A special diagrammatic technique is introduced as a tool for database design. An example of database design and description using the model and the diagrammatic technique is given. Some implications for data integrity, information retrieval, and data manipulation are discussed.

The entity-relationship model can be used as a basis for unification of different views of data: the network model, the relational model, and the entity set model. Semantic ambiguities in these models are analyzed. Possible ways to derive their views of data from the entity-relationship model are presented.

Key Words and Phrases: database design, logical view of data, semantics of data, data models, entity-relationship model, relational model, Data Base Task Group, network model, entity set model, data definition and manipulation, data integrity and consistency
CR Categories: 3.50, 3.70, 4.33, 4.34

2.1. Introduction.

An **ER model**…

…is a conceptual data model that views the **real world** as…

…**entities** and **relationships**.

An **ER model**…

…is **useful for a DB designer** in 3 ways:

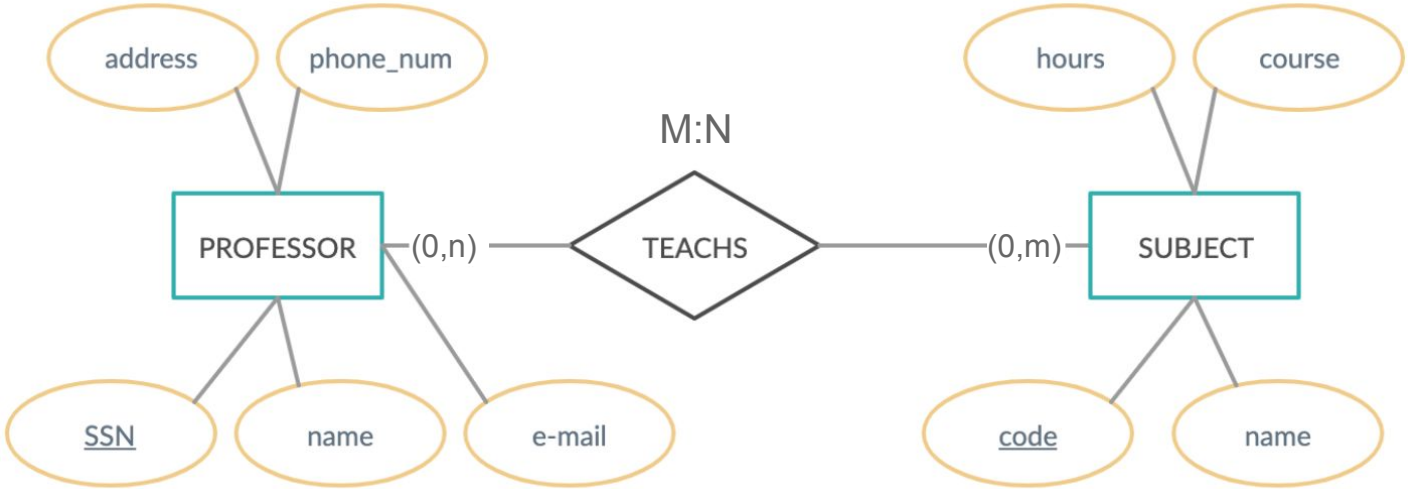
1. It can be **mapped to relational model.**

2. It can be used **to communicate the design** of the database **to the end user.**

3. It's **independent of a concrete DBMS** software.

2.2. Basic concepts.

It’s based on the perception of the real world as a collection of basic objects called **entities** and the **relationships** between these objects. The information we need from entities or relationships are the **attributes**.



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2.2. Basic concepts.

Main components:
Entities
Relationships
Attributes
Associative entities

2.3. Entities.

An **entity** is a ‘thing’ or ‘object’ of the real world that is distinguishable from all other objects. Examples: consumer goods, customers, invoices, students, professors, books, …

To name the object the **singular form** is usually used.

The entity is the **set of these objects** as a group.

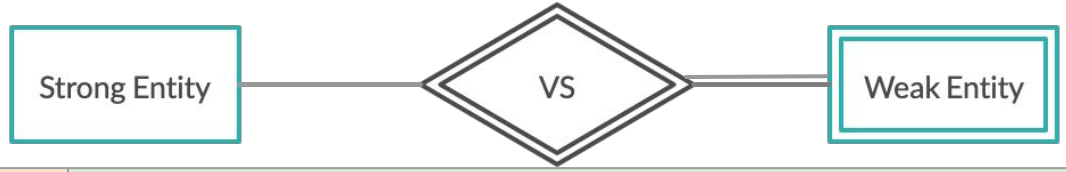
The **instances**, occurrences, or members of an entity are each of the individual objects that are part of an entity.

2.3. Entities.

Every **entity** must have the following characteristics:

- Each instance **must be <u>unambiguously identified</u>** (there must be some way to differentiate two individual instances of an entity).
- Each entity plays a **role within the system** (the system will not work without accessing its members –instances–).
- Each entity can be **described by** one or more elementary data (**attributes**). The attributes are applied to each instance of the entity.

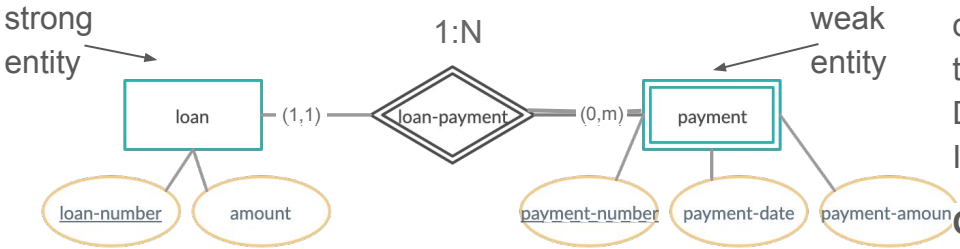
2.3. Entities: Types.



Strong entities:	**Weak entities**:
The ones whose **existence does not depend on the existence of any other entity** in a schema.	The ones that **depends on a strong entity for its existence**.
It is denoted by a **single rectangle**.	It is denoted by the **double rectangle**.
A strong entity always has the **primary attribute or identifier** in the set of attributes that describes the strong entity (we will see this later). It indicates that each entity in a strong entity set can be uniquely identified.	Weak entity **do not have a identifier**, instead it has a **partial identifier (or discriminator)** that uniquely discriminates the weak entities. The **identifier of a weak entity** is a **composite identifier formed from the primary attribute of the strong entity and discriminator of the weak entity**.

2.3. Entities: Types.

Example 1: In the below ER Diagram, 'Payment' is the weak entity. 'Loan Payment' is the identifying relationship and 'Payment Number' is the partial identifier. Main identifier of the Loan along with the partial identifier would be used to identify the records.



Example 2: The existence of rooms is entirely dependent on the existence of a hotel. So room can be seen as the weak entity of the hotel.

Example 3: The bank account of a particular bank has no existence if the bank doesn't exist anymore.

Example 4: A company may store the information of dependants (Parents, Children, Spouse) of an Employee. But the dependants don't have existence without the employee. So Dependent will be weak entity type and Employee will be Identifying Entity type for Dependant.

Other examples:

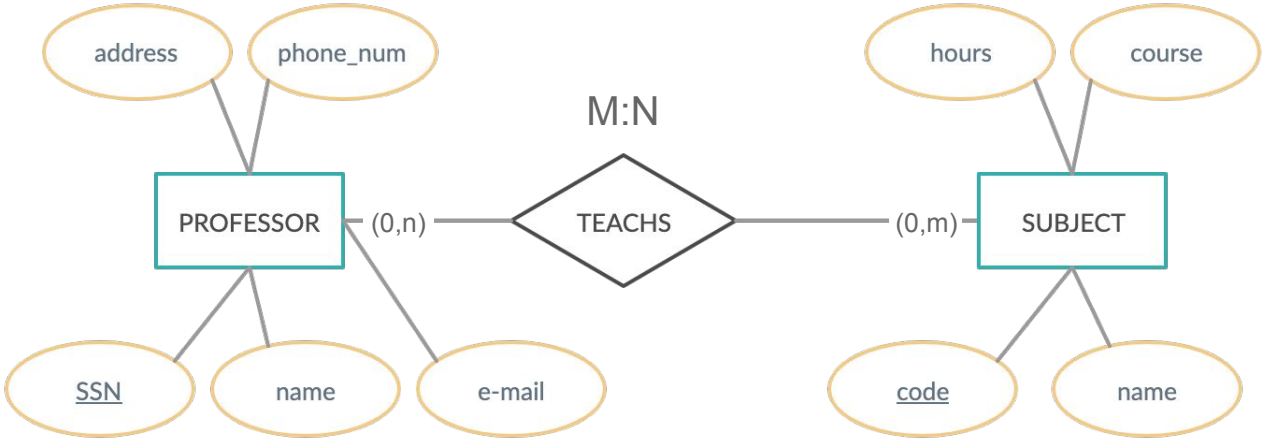
Strong entity	**Weak entity**
Host	Logins
Brand	Model

Copied from: https://www.geeksforgeeks.org/weak-entity-set-in-er-diagrams/

2.4. Attributes.

Attributes

Data that we need to keep from each entity, associative entity or relationship.



2.4. Attributes: Types.

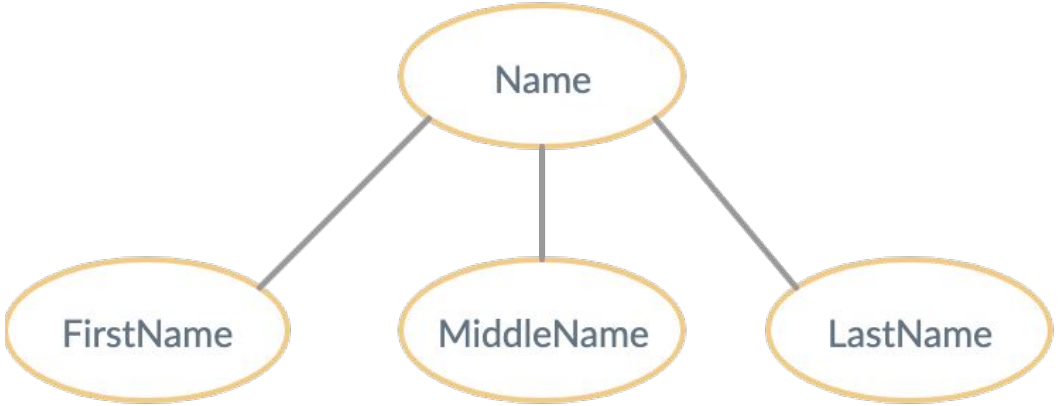
Simple and Single-Valued

It is an attribute consisting of only one field.

2.4. Attributes: Types.

Composite

It is an attribute consisting of multiple fields. It is denoted by many ellipses containing individual field names joined to a single ellipse containing the composite attribute.



2.4. Attributes: Types.

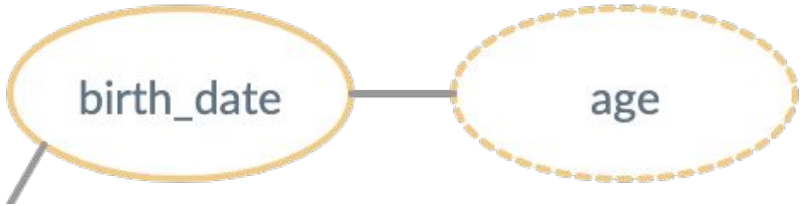
Multivalued

It is an attribute that has multiple values. Example: phone number and e-mails can have multiple values for a person. It is denoted by coinciding ellipses.

2.4. Attributes: Types.

Derived

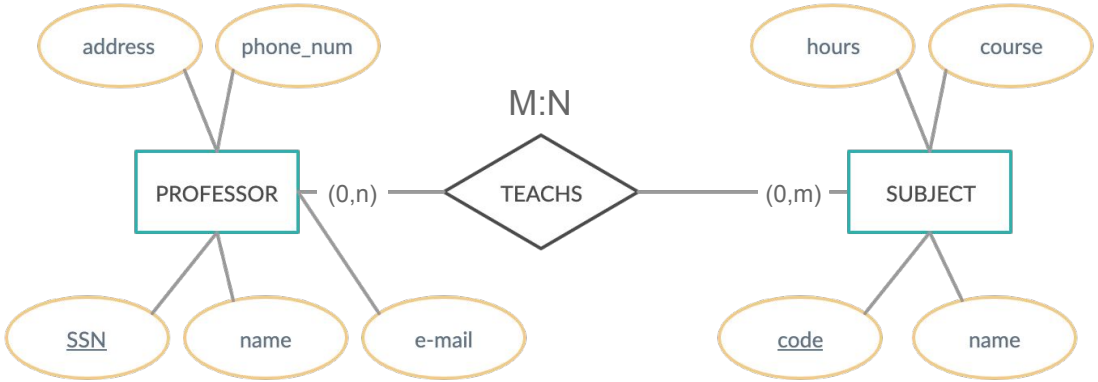
It is an attribute that is not physically stored in the database can be extracted from existing attributes. Example: age can be extracted from the difference between date of birth and current date. It is denoted by dotted ellipses.



2.4. Attributes: Types.

Identifier or Primary Attribute

An identifier (primary key in the relational model) is one or more attributes in an entity that uniquely identifies an entity occurrence (i.e. no other entity occurrence can contain the same key).



2.4. Attributes: Types.

Identifier or Primary Attribute:
Often, people introduce attributes (="**artificial identifiers**") whose role is to serve as an identifier for entities.
Companies assign employee IDs to all employees, and these IDs are carefully chosen to be unique numbers. But employees have a SSN, Students IDs in universities, driver license numbers,, etc.
Only use an "artificial" identifier if you can not use as identifier one of the attributes that already exist in the entity.

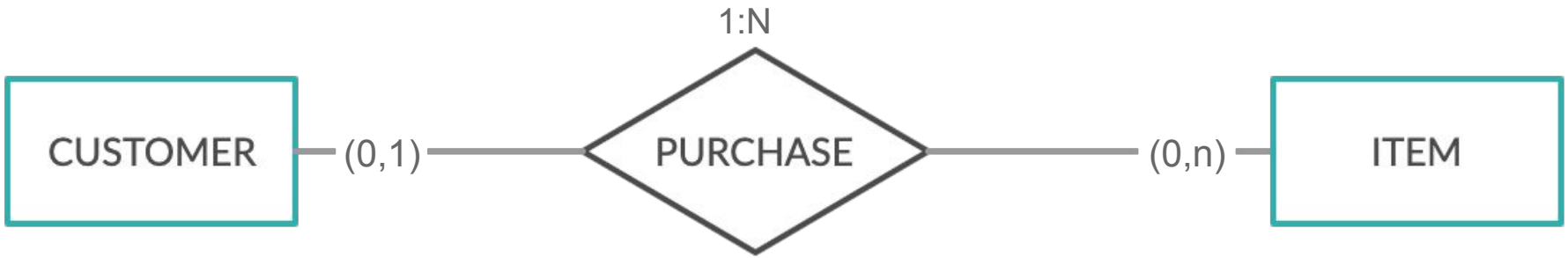
2.4. Attributes: Types.

Discriminator or Partial Identifier

For weak entity, the attribute that uniquely identifies it is called as a discriminator. Example: Receipt number when payment is a weak entity depending on the loan entity. It is denoted by an ellipse with dotted underline underneath the attribute name.

2.5. Relationships.

Relationships:
Entities are linked to each other **by relationships**.
Every relationship must have a **name**.
A relationship does not exist by itself. It needs the entities to make sense.

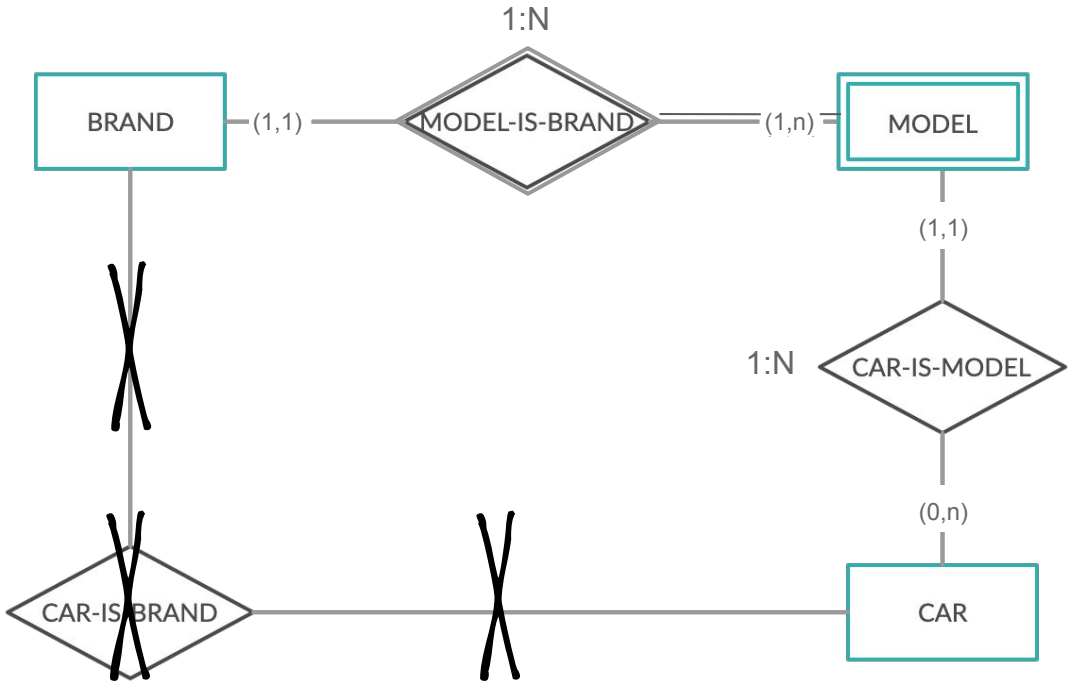


2.5. Relationships.

Relationships:

The relationship represents **something that must be remembered in the system**, something that **can not be calculated or derived** from other data in the system.

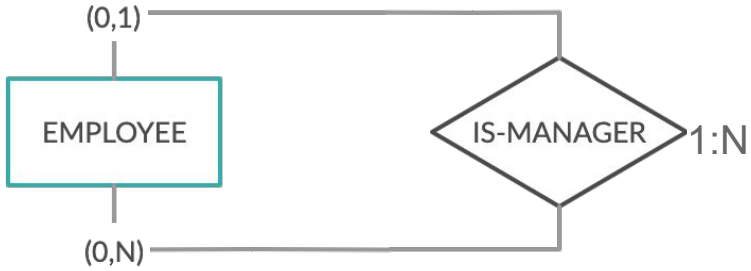
The relationship that can be calculated or derived from other data must **NOT** be represented.

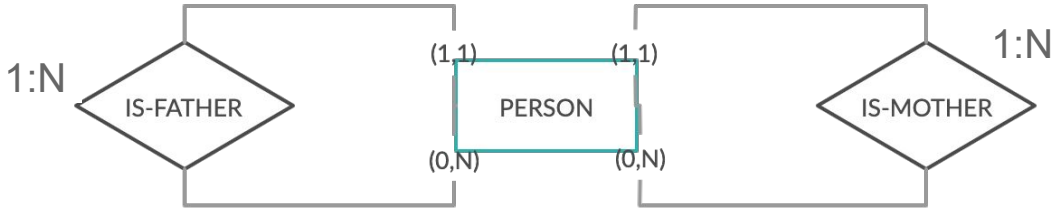


2.5. Relationships: Types.

Unary (or Recursive) Relationship

Relationship which associates an entity of the same type to itself.

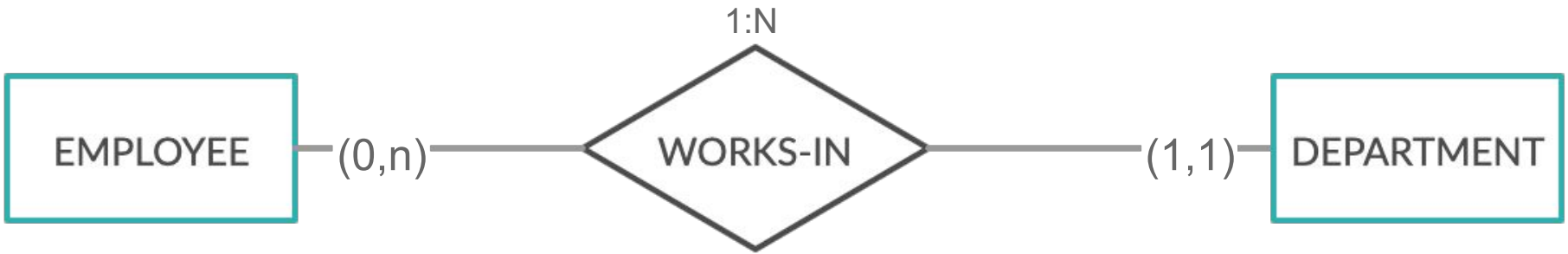




2.5. Relationships: Types.

Binary Relationship

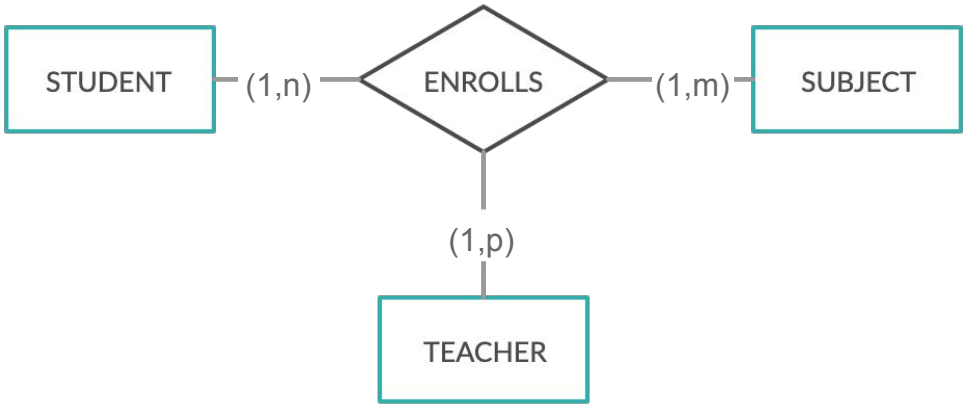
Relationship which associates one entity to another entity.



2.5. Relationships: Types.

Ternary Relationship

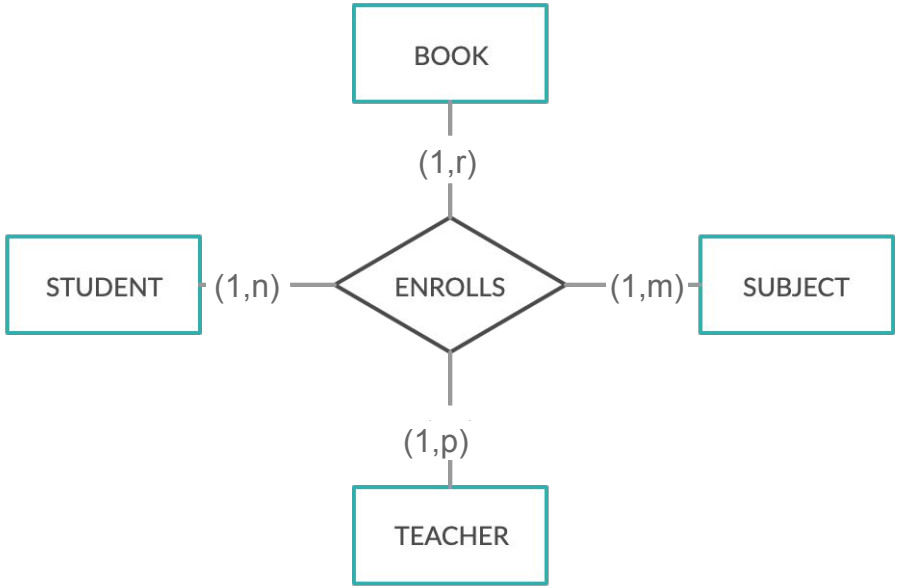
Relationship in which 3 entities are associated to each other using a single relationship ("enrolls" needs the 3 entities to exist).



2.5. Relationships: Types.

Quaternary Relationship

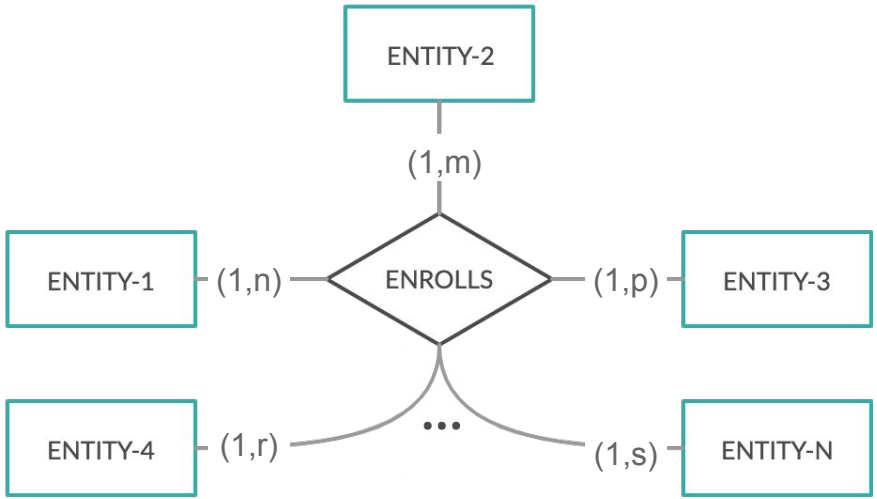
Here 4 entities take part in the relationship and together have to co-exist to make the relationship possible.



2.5. Relationships: Types.

N-ary Relationship

Here n-entities take part in a relationship simultaneously to make the relationship to exist.



VERY IMPORTANT: N-ary Relationship be understood as a unit. The relationship must be studied from the perspective of each of the participating objects. It is the set of all those perspectives who completely describes the interrelation.

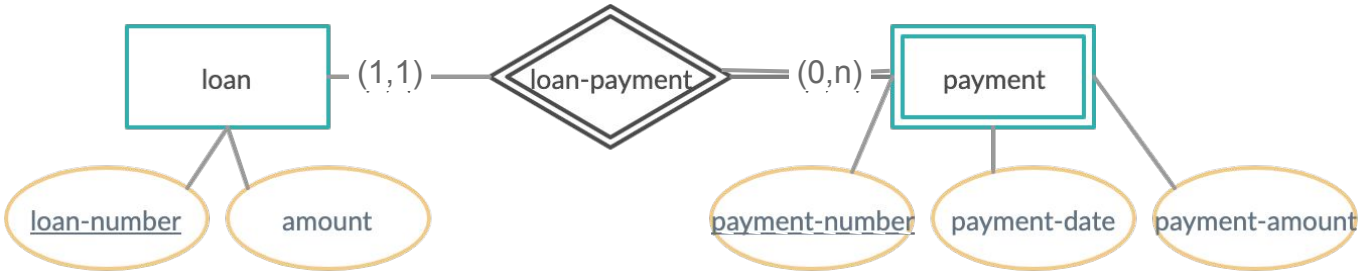
2.5. Relationships: Types.

Strong relationship

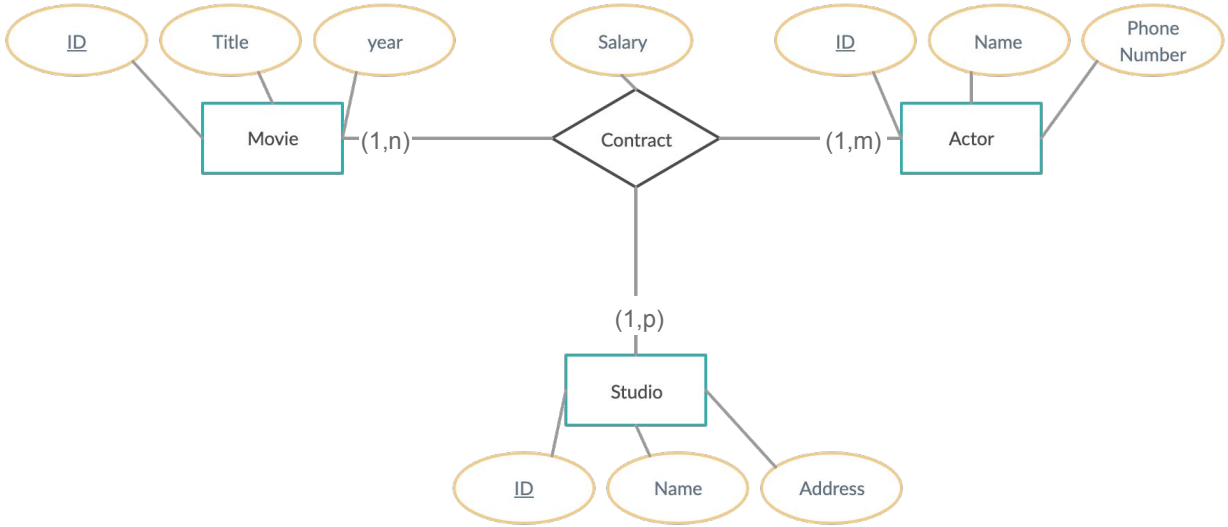
Relationship which associates several strong entities.

Weak relationship

Relationship which associates a strong entity with a weak entity.



2.5. Relationships: Attributes of a relationship.



We wish to record the salary associated with a contract.

Can't associate it with the Actor entity because an actor/actress might get different salaries for different movies.

Doesn't make sense to associate it with a studio or with a movie.

However, it's appropriate to associate a salary with the (actor movie, studio) triple in the relationship set for the Contract relationship.

2.6. Constraints.

Constraints
An E-R diagram has certain constraints the contents of the database must follow. The two main types constraints are:
● Cardinality or degree of a relationship.
● Optional relationships.

2.6. Constraints: Cardinality or degree of a relationship.

One-to-one (1:1)

This is where one occurrence of an entity relates to only one occurrence in another entity.

A one-to-one relationship rarely exists in practice, but it can. However, you may consider combining them into one entity.

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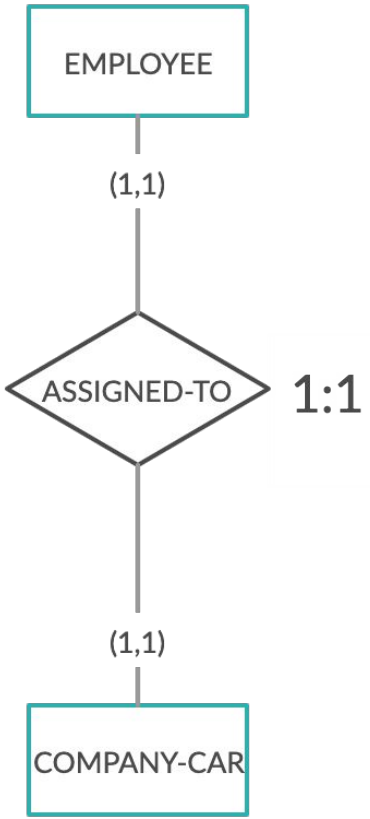
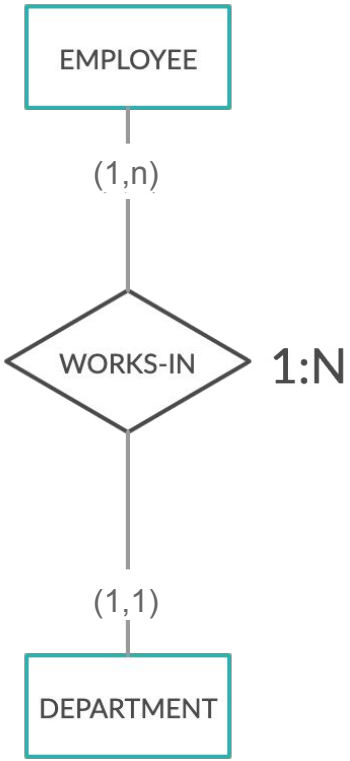


2.6. Constraints: Cardinality or degree of a relationship.

One-to-Many (1:N)

Is where one occurrence in an entity relates to many occurrences in another entity.



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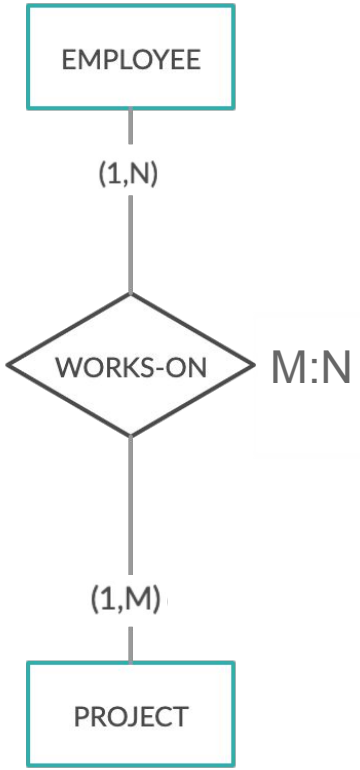
2.6. Constraints: Cardinality or degree of a relationship.

Many-to-Many (M:M or M:N or N:M)

This is where many occurrences in an entity relate to many occurrences in another entity.



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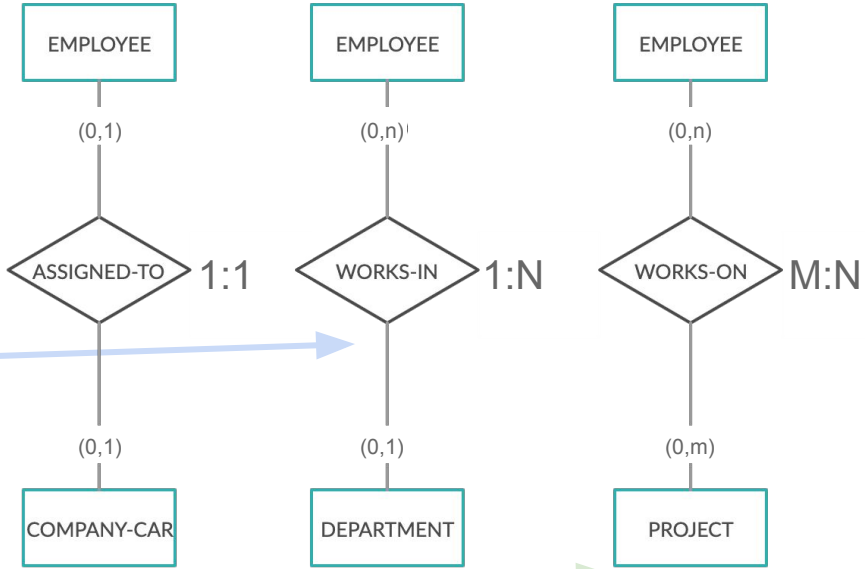
2.6. Constraints: Optional Relationships.

A relationship may also be **optional** (defined by the business rules).

Not all employees have a company car. A car may not have assigned an employee.

A new department is created with no employees in it. But an employee MUST have a department.

A new project is defined with no employees working on it. A new employee starts within the company but he/she couldn't have any project assigned.



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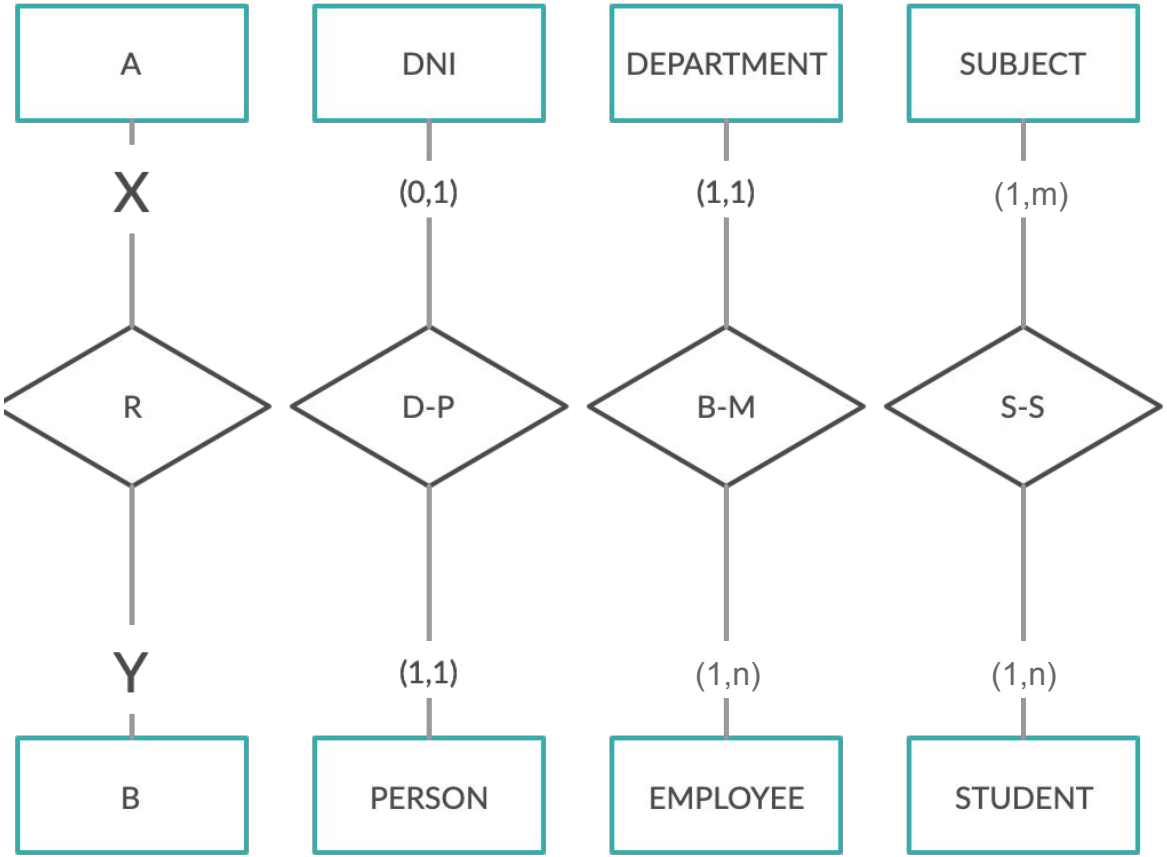
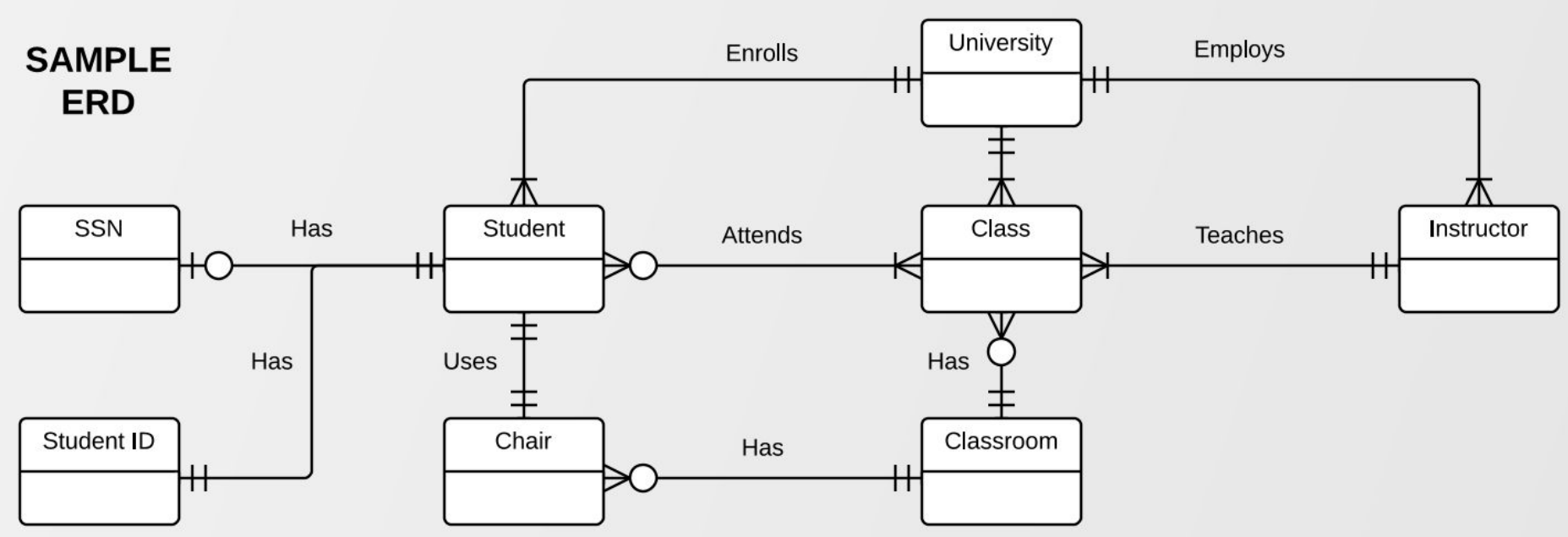
2.6. Constraints: Optional Relationships.

1 or (1,1)	1 and only 1
0,1 or (0,1)	0 or 1
n or (0,n)	0 or more
1,n or (1,n)	1 or more
~~n+~~	~~more than 1~~ ~~(not 0, not 1)~~

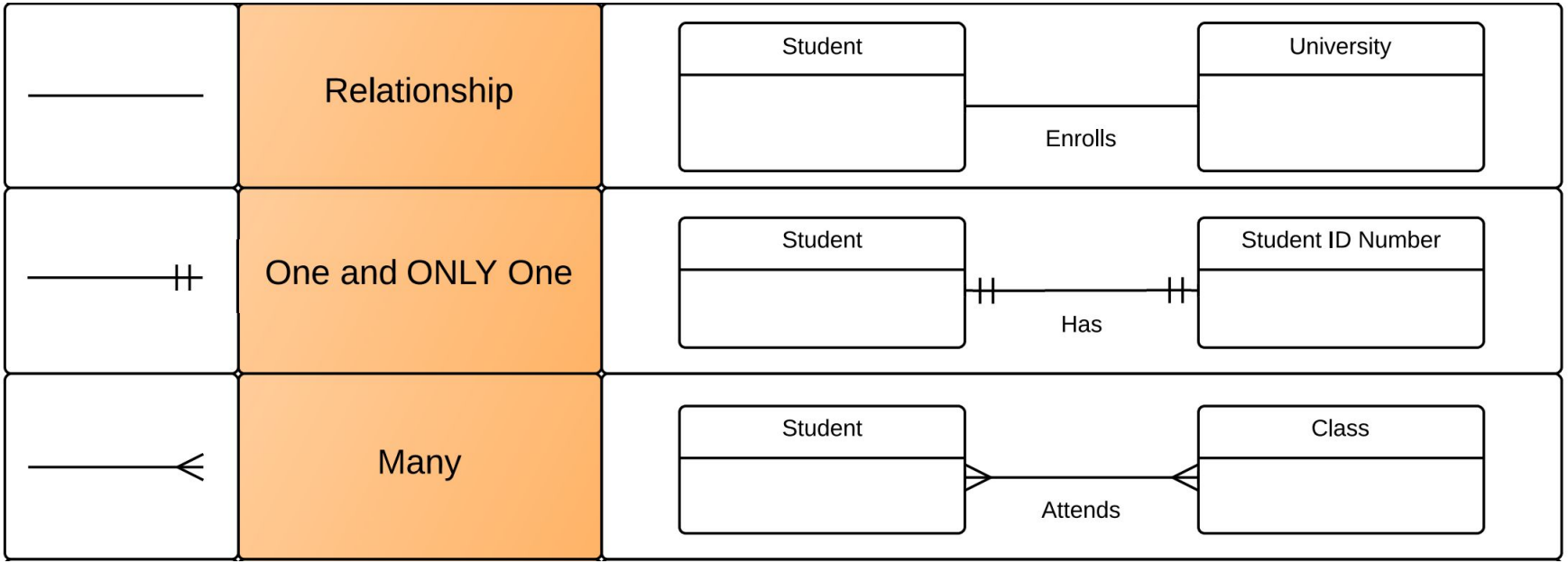


2.6. Constraints: Cardinality or degree of a relationship (Crow's Foot).



Source: https://www.cs.dartmouth.edu/~cs61/Resources/ERD_Relationship_Symbols_Quick_Reference.pdf
More info: https://stackoverflow.com/questions/33781451/crows-feet-one-vs-one-and-only-one

2.6. Constraints: Cardinality or degree of a relationship (Crow's Foot).



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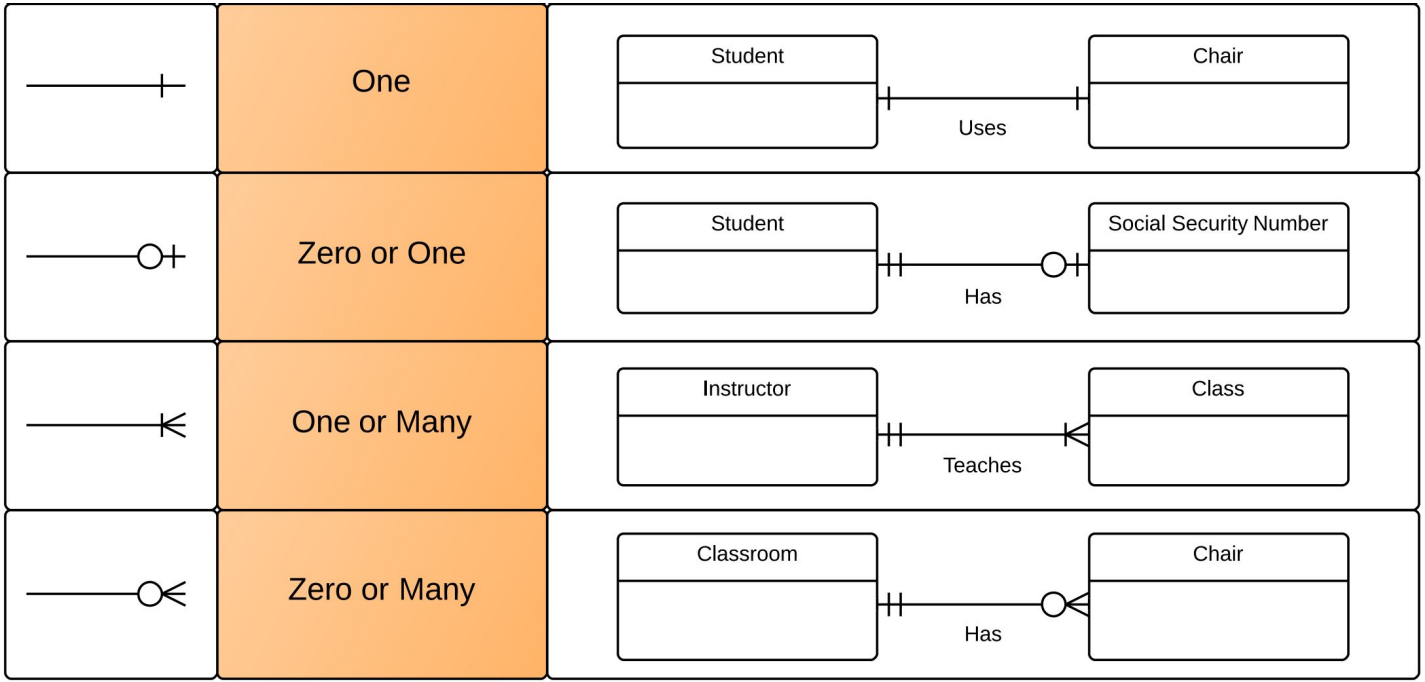
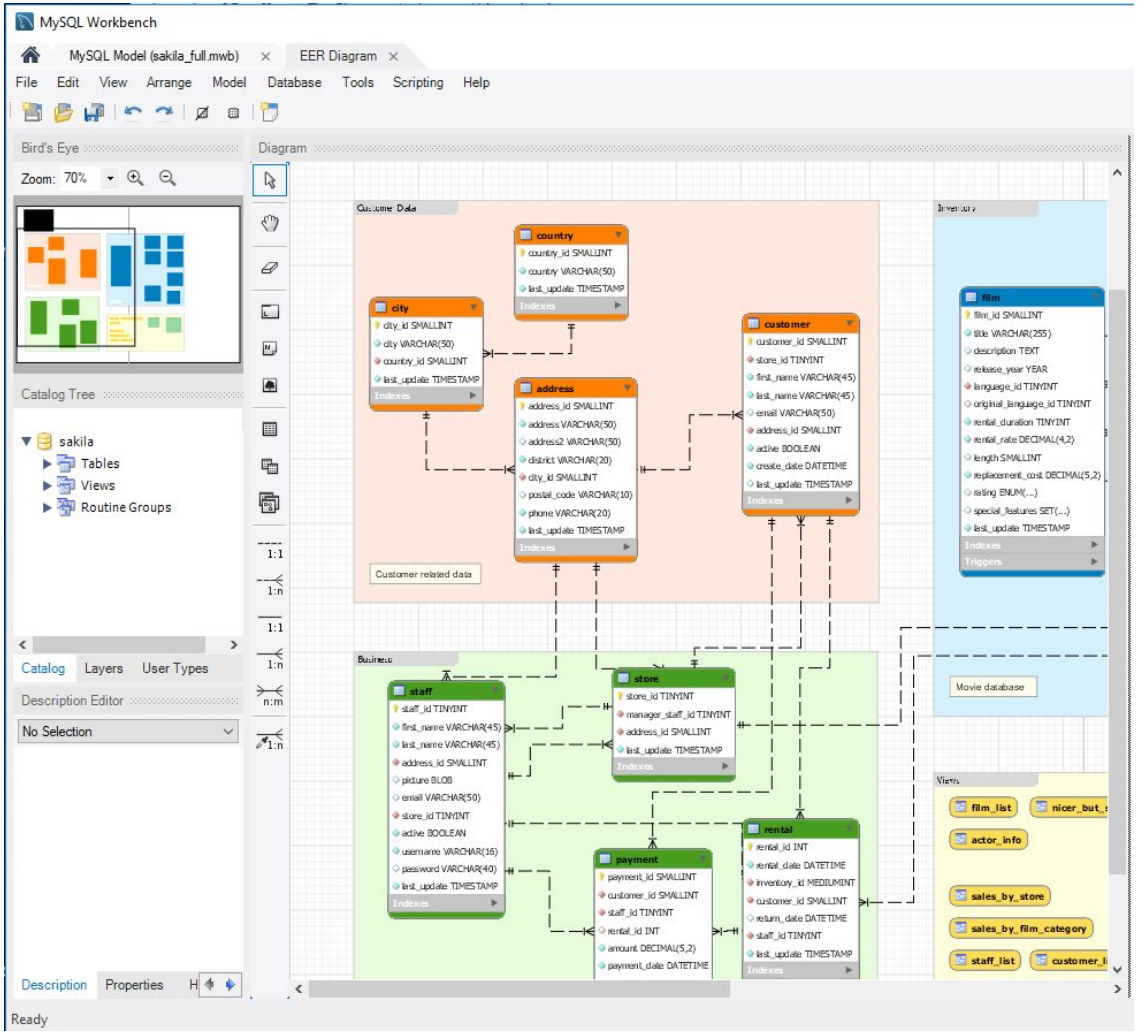


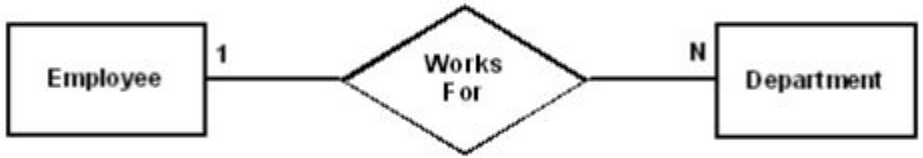
Source: https://www.cs.dartmouth.edu/~cs61/Resources/ERD_Relationship_Symbols_Quick_Reference.pdf

MySQL Workbench… BUT THIS IS RELATIONAL MODEL!!



2.6. Constraints: Cardinality or degree of a relationship.

(a) Look Across



(b) Look Here

FIGURE 2
Look Across and Look Here Notation

One binary relationship representing the following two sentences.
"One employee works for only one department. One department can have many employees."

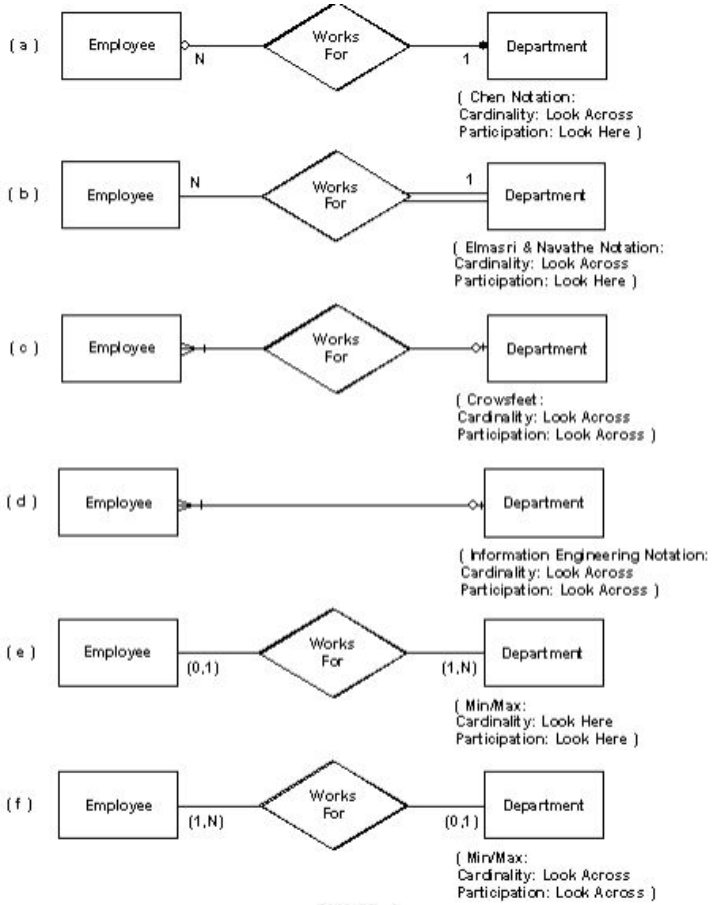
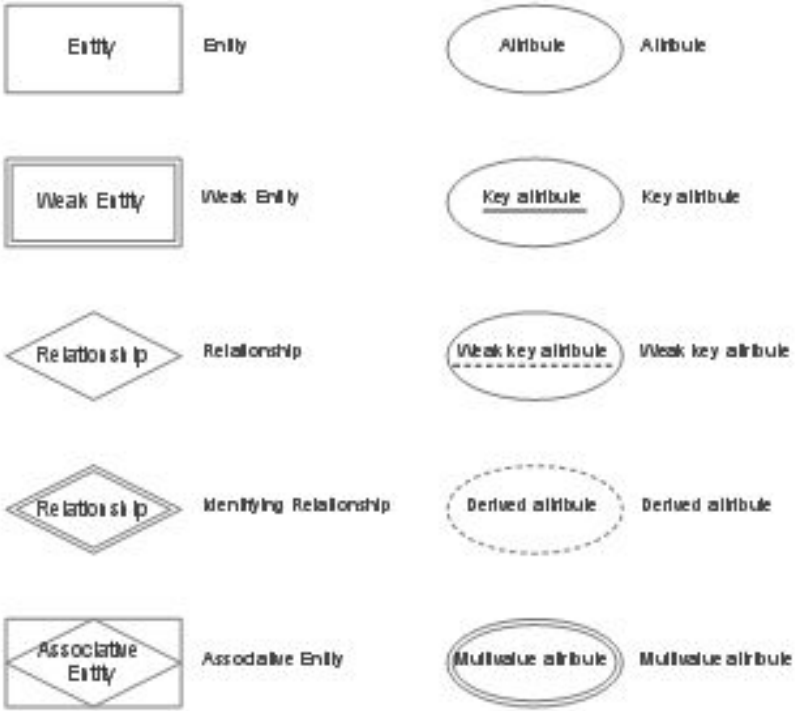
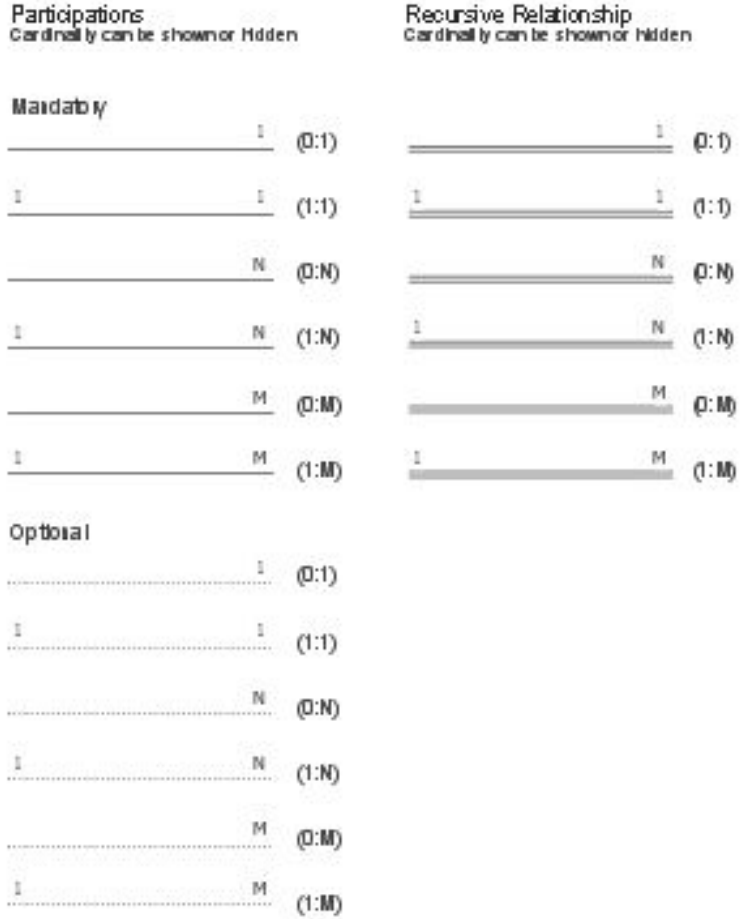


FIGURE 3
Various Notations for Cardinality and Participation Constraints showing "one employee can work for zero or one department and a department can have one or more employees."

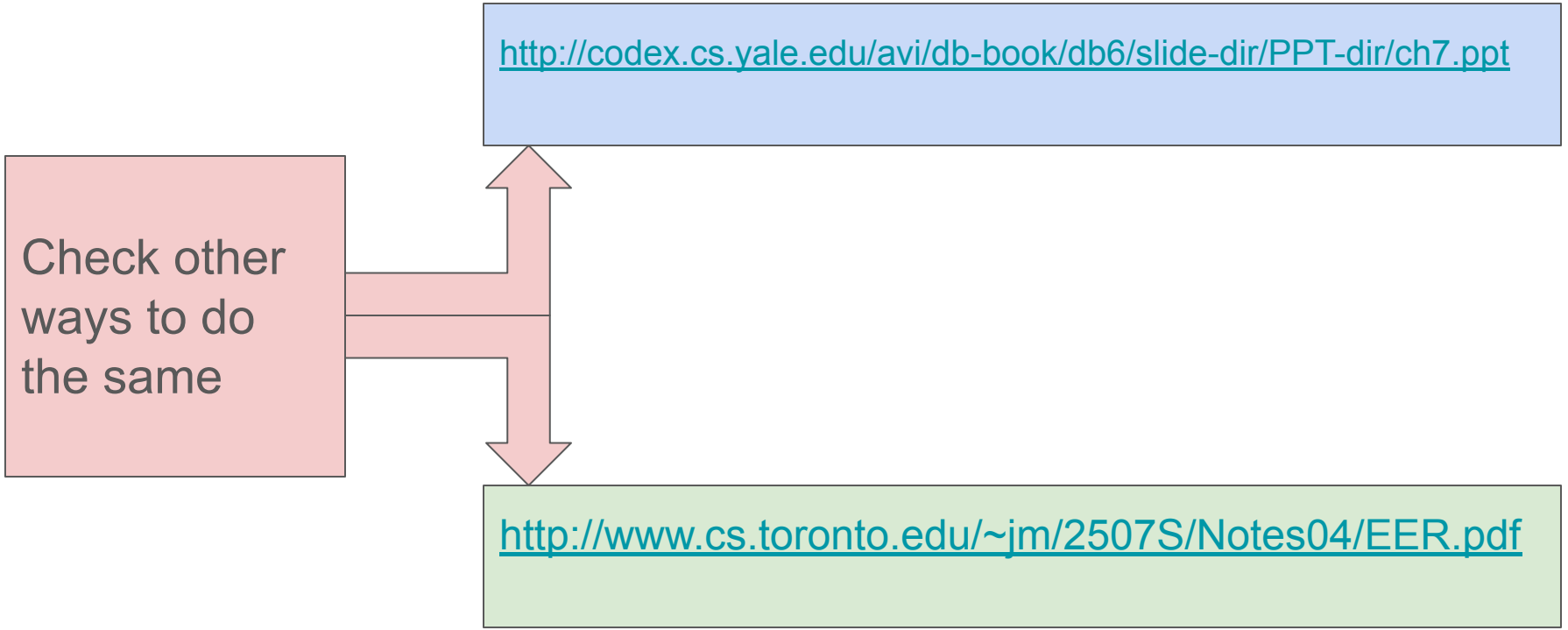
Chen notation





More things about Chen's notation here.

2.6. Constraints: Cardinality or degree of a relationship.



an

2.7. Associative entity.

An **associative entity**…

…represents something that **works as an entity and as a relationship** at the same time.

…represents a **relationship with information to be maintained and/or to be interrelated with other entities**.

Associative entities are used when you need a relationship to be involved in a relationship.

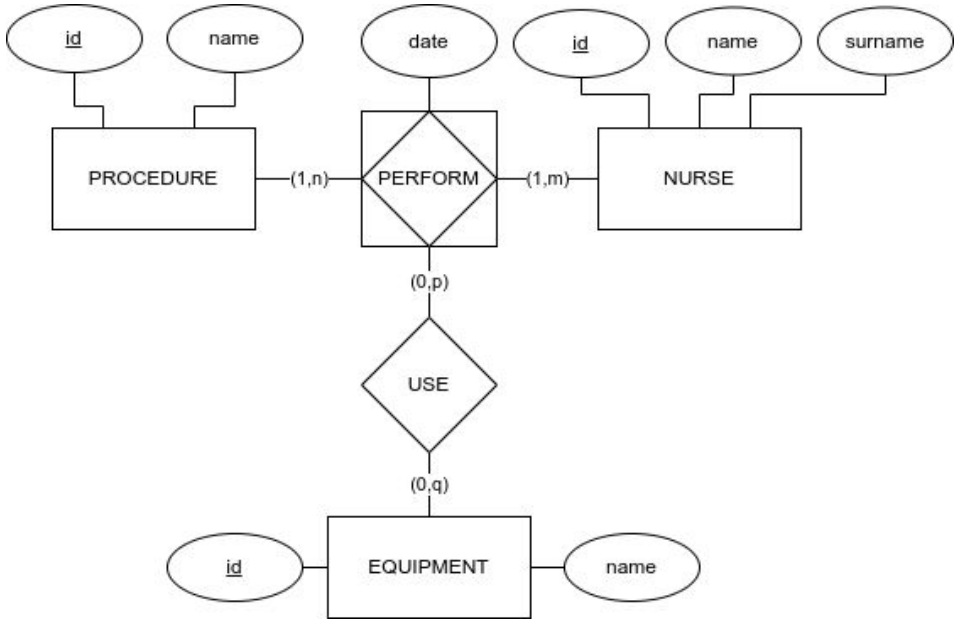
An associative entity use to relate to entities in an **N:M** relationship.

2.7. Associative entity.

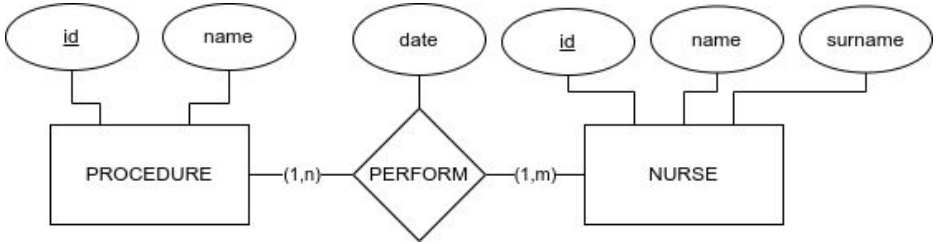
PERFORM works as (original idea is here):

- **Entity**: Because you can keep information associated with the performance of a procedure (date, hour, etc.), and because it is necessary to interrelate it with the EQUIPMENT entity.

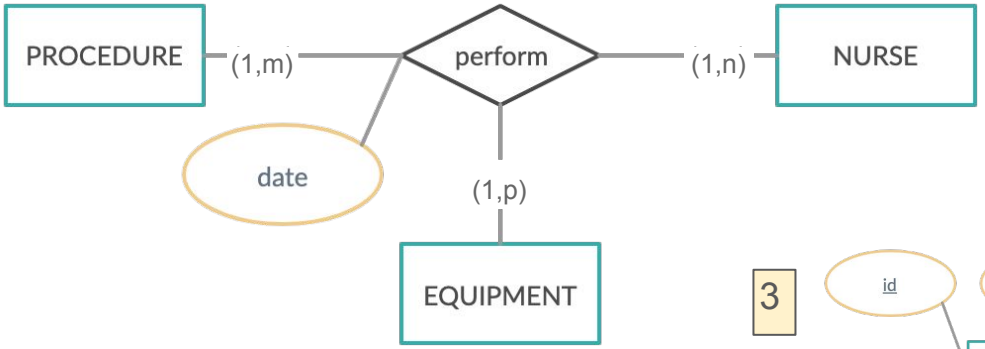
- **Relationship**: Because it connects PROCEDURE entities and NURSE entities. The relationship is as follows:
  - PROCEDURE and NURSE exist by themselves (regardless whether a procedure is ever performed or not).
  - PERFORM only exists as the result of the partnership between PROCEDURE and NURSE.



1



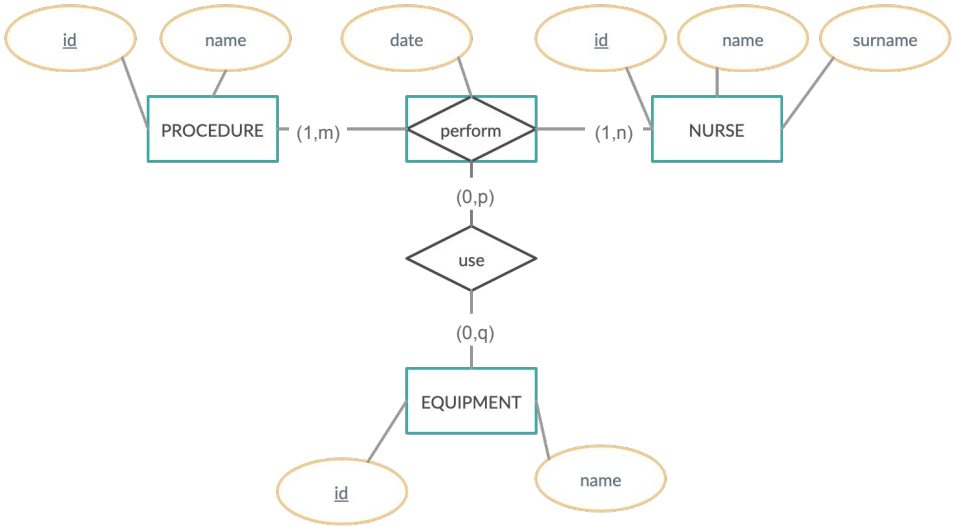
2



We don't keep if the nurses use equipment in a procedure.

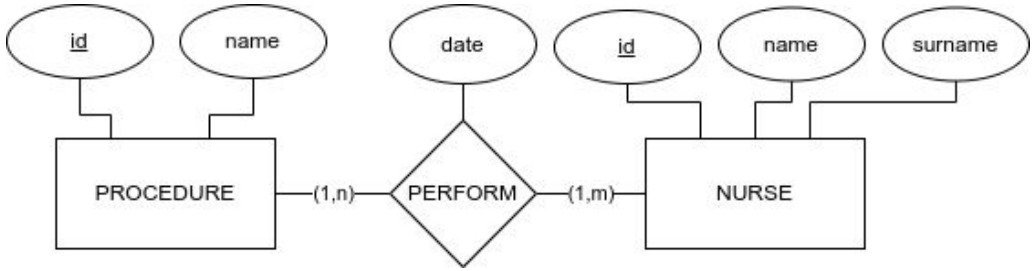
We keep equipment used by every nurse in the performance of a procedure. Nurses must use equipment! What does it happen if a nurse doesn't use any equipment?

3



We keep equipment used by every nurse in the performance of a procedure. But we can have nurses who didn't use equipment.

1



We don't keep if the nurses use **equipment** in a procedure.

Procedures (id, name)
Nurses (id, name, surname)
Performs (proid*, nurid*, date)

Procedures

id	**name**
1	Wound Care
2	Intubation
3	Blood Transfusion
4	Catheterization

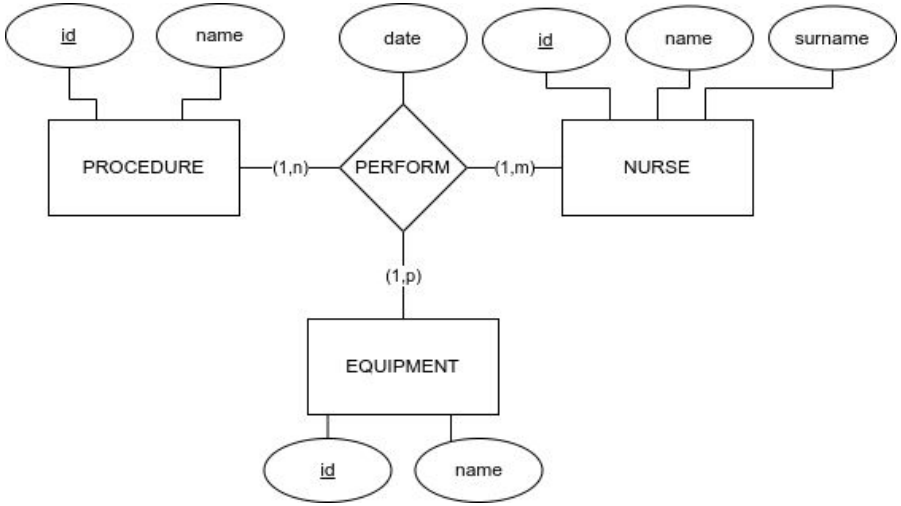
Nurses

id	**name**	**surname**
1	Sergi	González
2	Antoni	López
3	Xisca	Amengual
4	Pilar	Gomis

Performs

proid*	**nurid***	**date**
1	1	1/2/2022
1	1	2/2/2022
2	4	1/2/2022
4	4	2/2/2022

2



We keep equipment used by every nurse in the performance of a procedure. Nurses must use equipment! What does it happens if a nurse don't use any equipment?

Procedure (id, name)
Nurse (id, name, surname)
Perform (proid*, nurid*, equid*,date)
Equipment (id, name)

Procedures

id	name
1	Wound Care
2	Intubation
3	Blood Transfusion
4	Catheterization

Nurses

id	name	surname
1	Sergi	González
2	Antoni	López
3	Xisca	Amengual
4	Pilar	Gomis

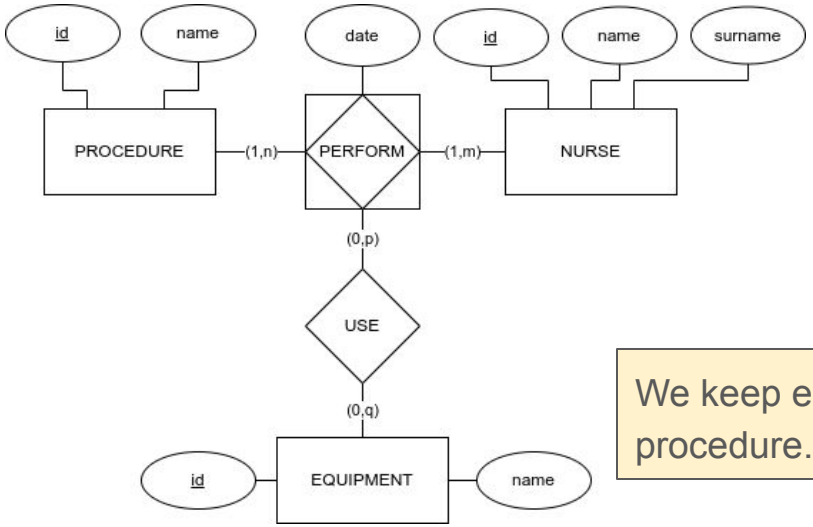
Performs

proid*	nurid*	equid*	date
1	1	4	1/2/2022
1	1	3	1/2/2022
1	2	4	1/2/2022
1	2	3	1/2/2022

Equipments

id	name
1	Sterile catheter
2	Endotracheal tubes
3	Non-Woven Sponge
4	Alcohol Pads

3



Procedure (id, name)
Nurse (id, name, surname)
Perform (proid*, nurid*,date)
Equipment (id, name)
Use (proid*, nurid*, date, equid*)

We keep equipment used by every nurse in the performance of a procedure. But we can have nurses who didn't use equipment.

Procedures

id	name
1	Wound Care
2	Intubation
3	Blood Transfusion
4	Catheterization

Nurses

id	name	surname
1	Sergi	González
2	Antoni	López
3	Xisca	Amengual
4	Pilar	Gomis

Performs

proid*	nurid*	date
1	1	1/2/22
1	1	2/2/22
2	4	1/2/22
4	4	2/2/22

Equipments

id	name
1	Sterile catheter
2	Endotracheal tubes
3	Non-Woven Sponge
4	Alcohol Pads

Uses

proid*	nurid*	date	equid*
1	1	1/2/22	4
1	1	1/2/22	3
~~2~~	~~4~~	~~1/2/22~~	~~2~~
~~4~~	~~4~~	~~2/2/22~~	~~1~~

Source: https://stackoverflow.com/questions/47150141/what-is-the-right-way-to-use-associative-entity?rq=1

2.7. Associative entity.

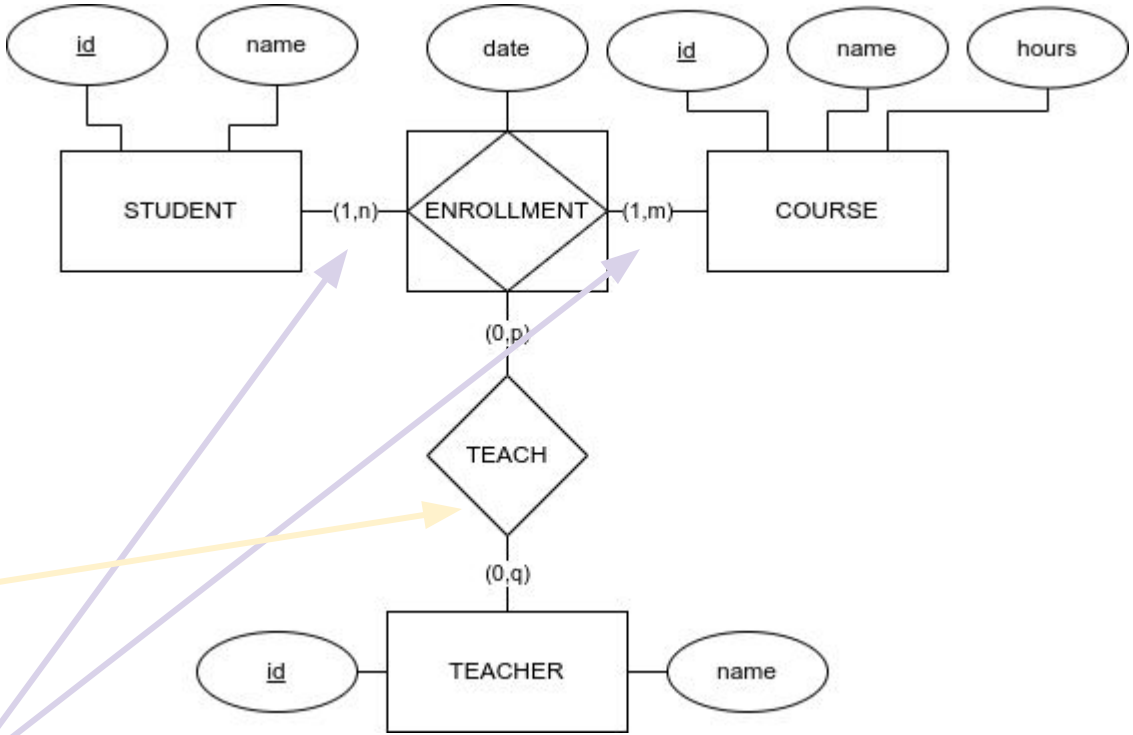
An **associative entity**…

…represents something that **works as an entity and as a relationship** at the same time.

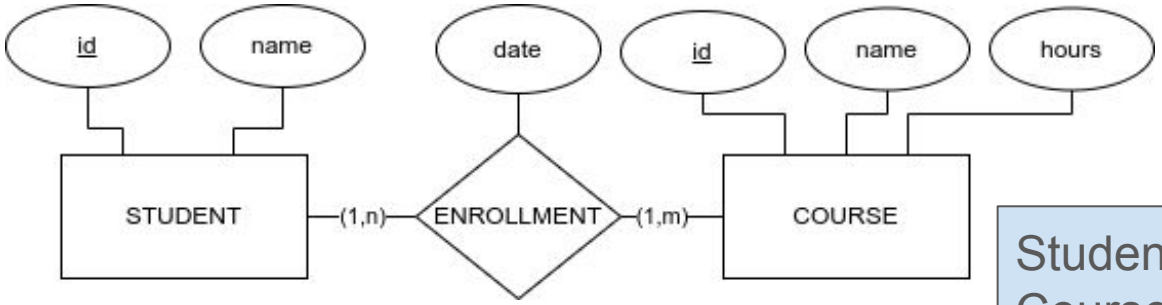
…represents a **relationship with information to be maintained and/or to be interrelated with other entities**.

Associative entities are used when you need a relationship to be involved in a relationship.

An associative entity use to relate to entities in an **N:M** relationship.



1



We don't know **who teaches the course**.

Students (id, name)
Courses (id, name, hours)
Enrollment (stuid*, couid*, date)

Students

id	**name**
1	Sergi González
2	Antoni López
3	Xisca Amengual
4	Pilar Gomis

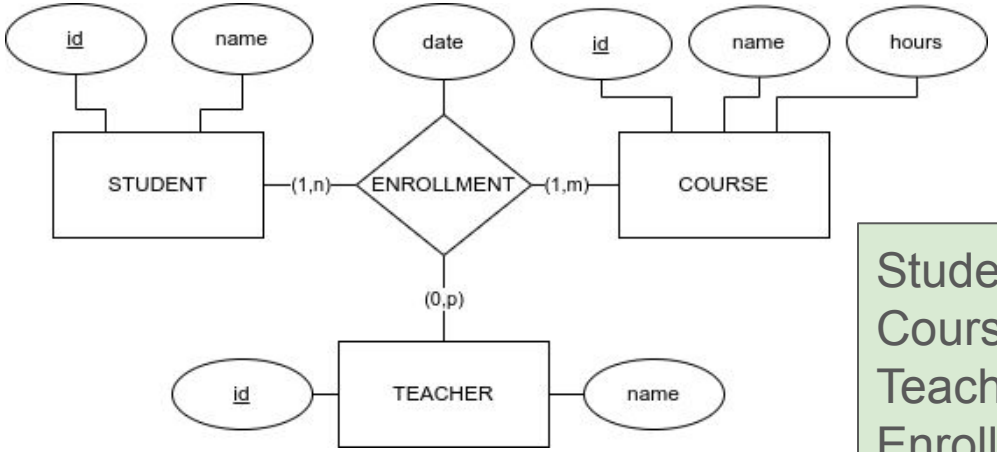
Courses

id	**name**	**hours**
1	Databases	270
2	Programming	320
3	Web design	240
4	Web services	170

ENROLLMENT

stuid*	**couid***	**date**
1	1	1/2/2022
1	2	1/2/2022
2	3	2/2/2022
2	4	2/2/2022

2



Every enrollment **MUST HAVE** a teacher assigned.

Students (<u>id</u>, name)
Courses (<u>id</u>, name, hours)
Teachers (<u>id</u>, name)
Enrollment (<u>stuid*, couid*, teaid*, date</u>)

Students

id	**name**
1	Sergi González
2	Antoni López
3	Xisca Amengual
4	Pilar Gomis

Courses

id	**name**	**hours**
1	Databases	270
2	Programming	320
3	Web design	240
4	Web services	170

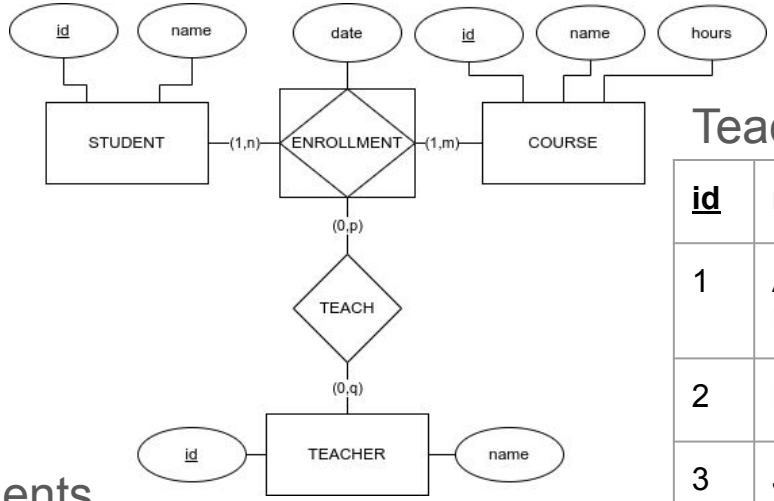
Teachers

id	**name**
1	Antonio Banderas
2	Kate Winslet
3	Julian Moore

Enrollment

stuid*	**couid***	**teaid***	**date**
1	1	1	1/2/22
1	2	1	1/2/22
2	3	2	2/2/22
2	4	2	2/2/22

3



There can be **enrollments without teacher**.

Students (id, name)
Courses (id, name, hours)
Teachers (id, name)
Enrollments (stuid*, couid*, date)
Teachs (stuid*, couid*, date, teadid*)

Teachers

id	name
1	Antonio Banderas
2	Kate Winslet
3	Julian Moore

Students

id	name
1	Sergi González
2	Antoni López
3	Xisca Amengual
4	Pilar Gomis

Courses

id	name	hours
1	Databases	270
2	Programming	320
3	Web design	240
4	Web services	170

Enrollments

stuid*	couid*	date
1	1	1/2/22
1	2	1/2/22
2	3	2/2/22
2	4	2/2/22

Teaches

stuid*	couid*	date	teaid*
1	1	1/2/22	1
1	2	1/2/22	1
2	3	2/2/22	2

2.7. Associative entity.

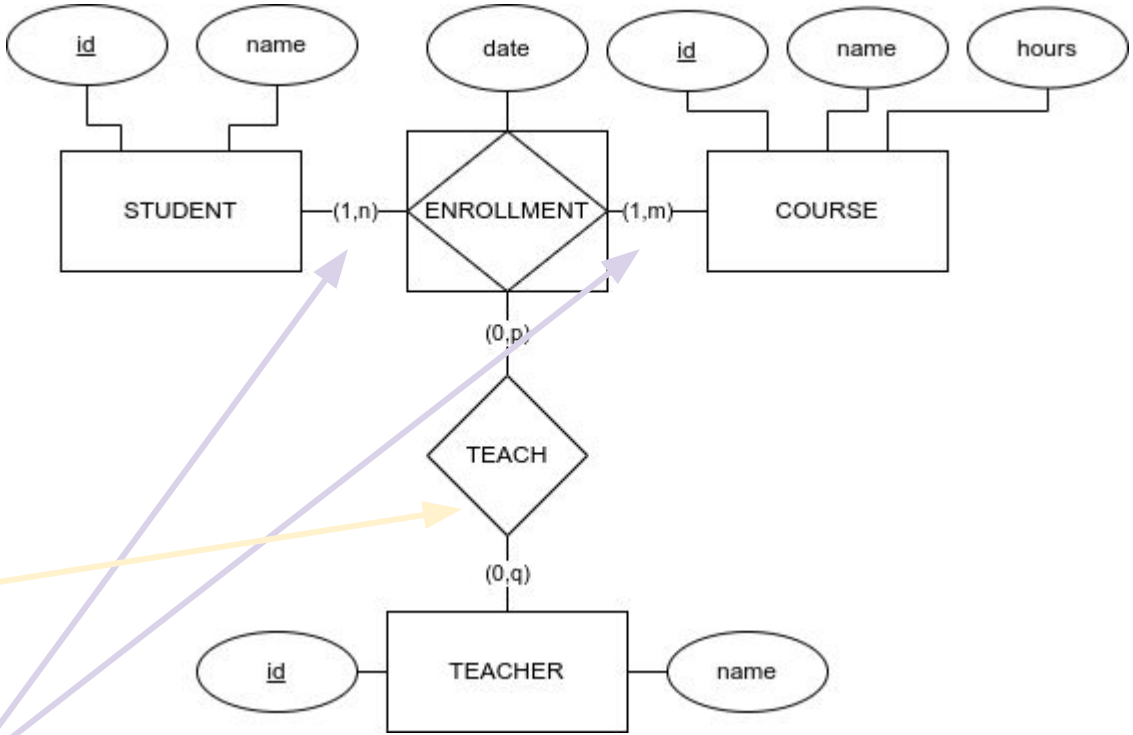
An **associative entity**…

…represents something that **works as an entity and as a relationship** at the same time.

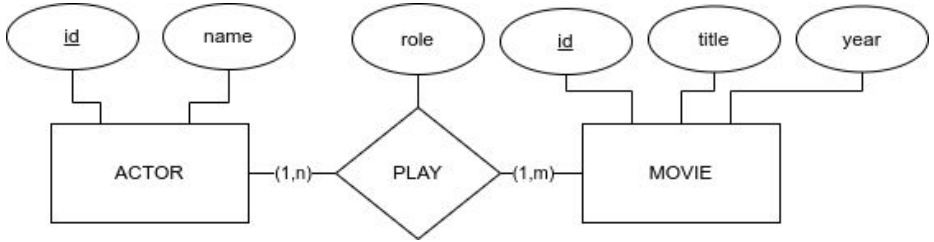
…represents a **relationship with information to be maintained and/or to be interrelated with other entities**.

Associative entities are used when you need a relationship to be involved in a relationship.

An associative entity use to relate to entities in an **N:M** relationship.



1



Actors (id, name)
Movies (id, title, year)
Plays (movid*, actid*, role)

Actors

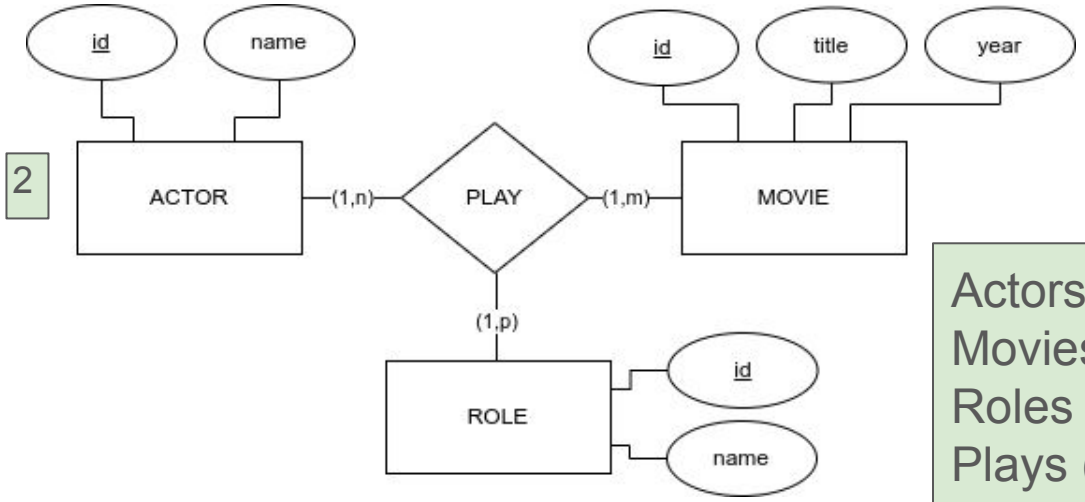
id	name
1	Antonio Banderas
2	Salma Hayek
3	Mark Wahlberg
4	Julian Moore

Movies

id	name	hours
1	Desperado	1995
2	Boogie Nights	1997
3	Casablanca	1955
4	The mummy	1999

Plays

movid*	actid*	role
1	1	leading
1	2	leading
2	3	leading
2	4	secondary



Actors (id, name)
Movies (id, title, year)
Roles (id, name)
Plays (movid*, actid*, role)

Actors

id	name
1	Antonio Banderas
2	Salma Hayek
3	Mark Wahlberg
4	Julian Moore

Movies

id	name	hours
1	Desperado	1995
2	Boogie Nights	1997
3	Casablanca	1955
4	The mummy	1999

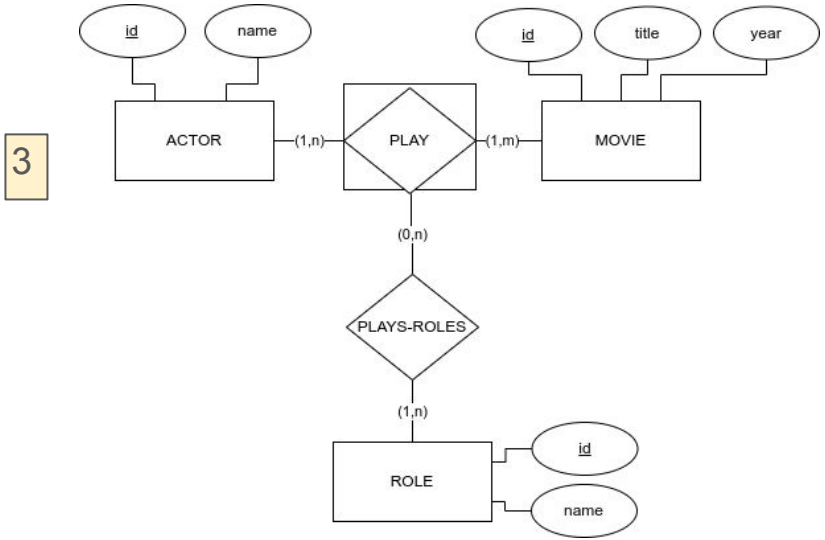
Roles

id	name
1	leading
2	secondary
3	extra

Plays

movid*	actid*	role
1	1	1
1	2	1
2	3	1
2	4	2

3



Actor/actress without a role in a movie??

Actors (id, name)
Movies (id, title, year)
Roles (id, name)
Plays (movid*, actid*)
Plays-Roles (movid*, actid*, rolid*)

Actors

id	name
1	Antonio Banderas
2	Salma Hayek
3	Mark Wahlberg
4	Julian Moore

Movies

id	name	hours
1	Desperado	1995
2	Boogie Nights	1997
3	Casablanca	1955
4	The mummy	1999

Roles

id	name
1	leading
2	secondary
3	extra

Plays

movid*	actid*
1	1
1	2
2	3
2	4

Plays-Roles

movid*	actid*	rolid*
1	1	1
1	2	1
2	3	1
2	4	2

2.8. Enhanced E-R Model.

Enhanced Entitiy-Relationship (EER) Model:

It appears due to the insufficiency of the E-R model for complex applications.

EER stands for Enhanced ER or Extended ER.

EER Model Concepts:

Includes all modeling concepts of basic ER.

Additional concepts:

- subclasses/superclasses
- inheritance
- exclusivity
- specialization/generalization

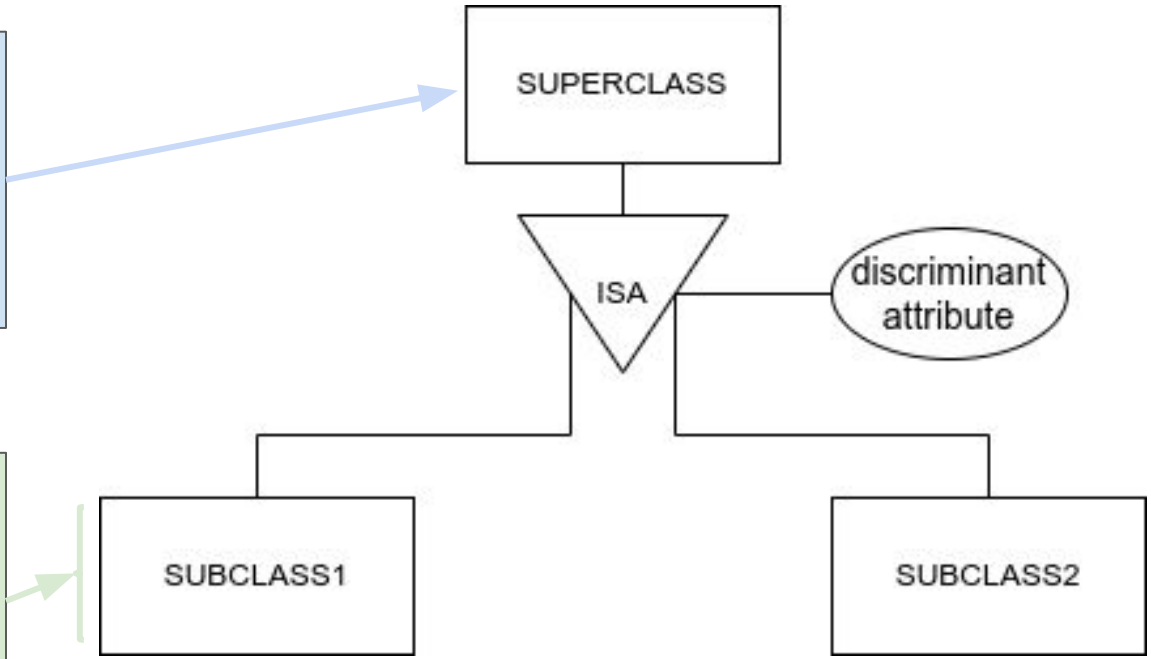
2.8. Subclasses and superclasses.

A subclass (subtype) …
…is a subset of occurrences of a entities of the same type (**superclass or supertype**) that need to be represented separately by application needs.
All these occurrences have some common characteristic.
E.g., secretary, technician, engineer, etc., could be subclasses of the a superclass called Employee.

2.8. Subclasses and superclasses.

superclass (supertype)

subclasses (subtypes)



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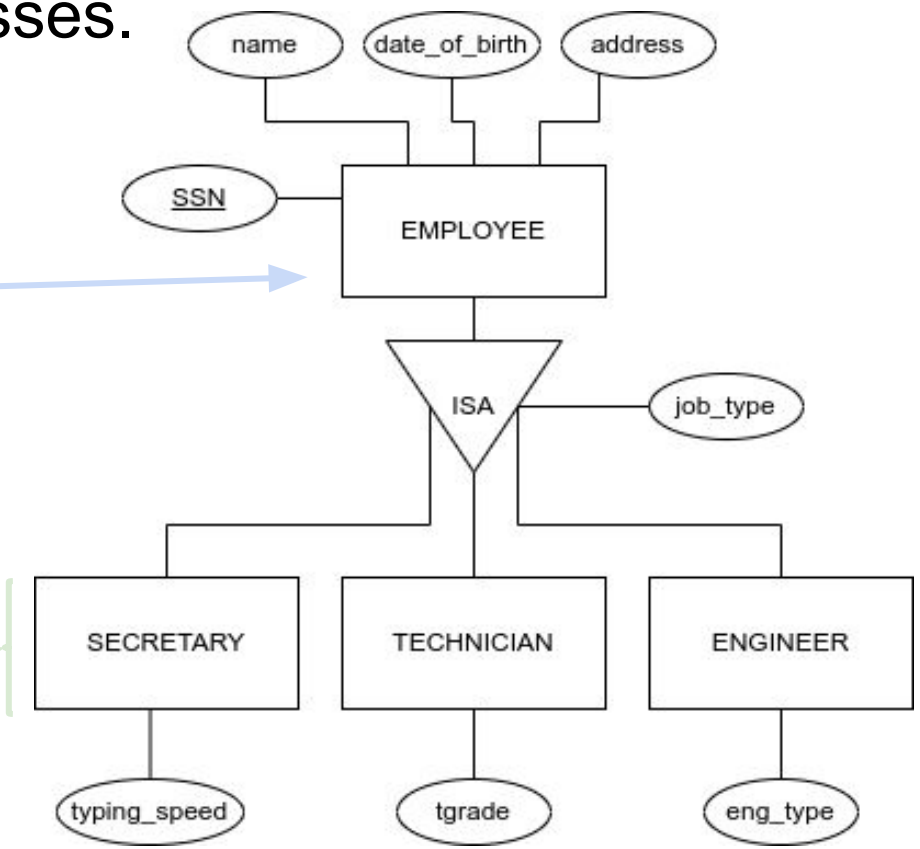
2.8. Subclasses and superclasses.

superclass (supertype)

subclasses (subtypes)



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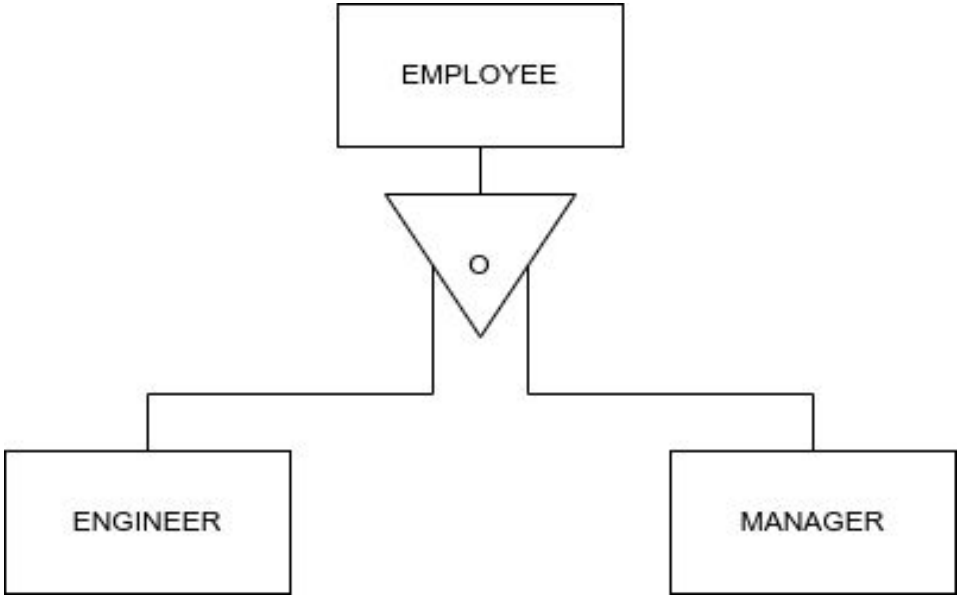
2.8. Subclasses and superclasses.

Overlapped

An employee could be an engineer or manager. But it could also be both! Or only a simple "employee"...

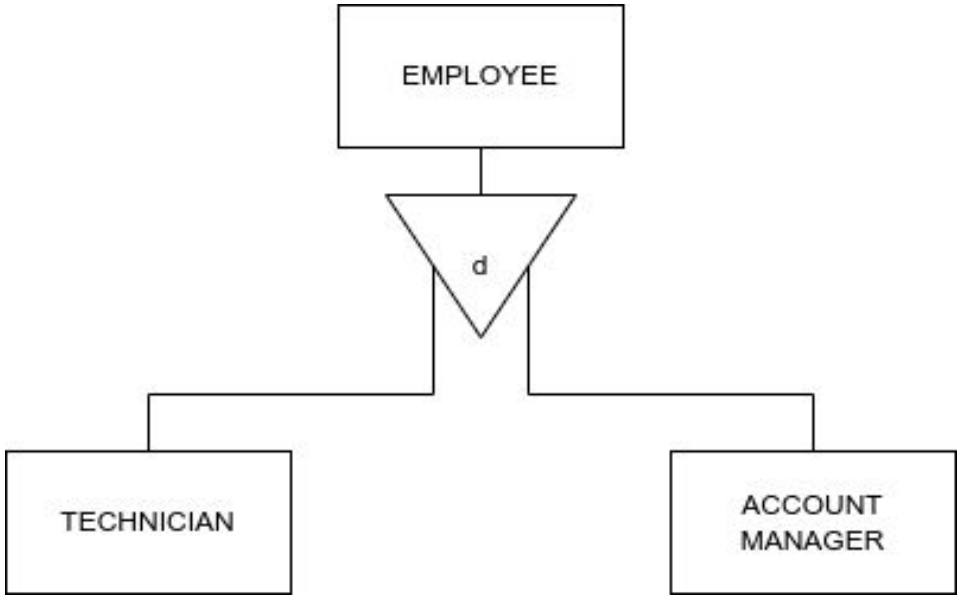


Created with diagrams.net.

2.8. Subclasses and superclasses.

Disjunct

An employee could be an engineer or manager. But only one!



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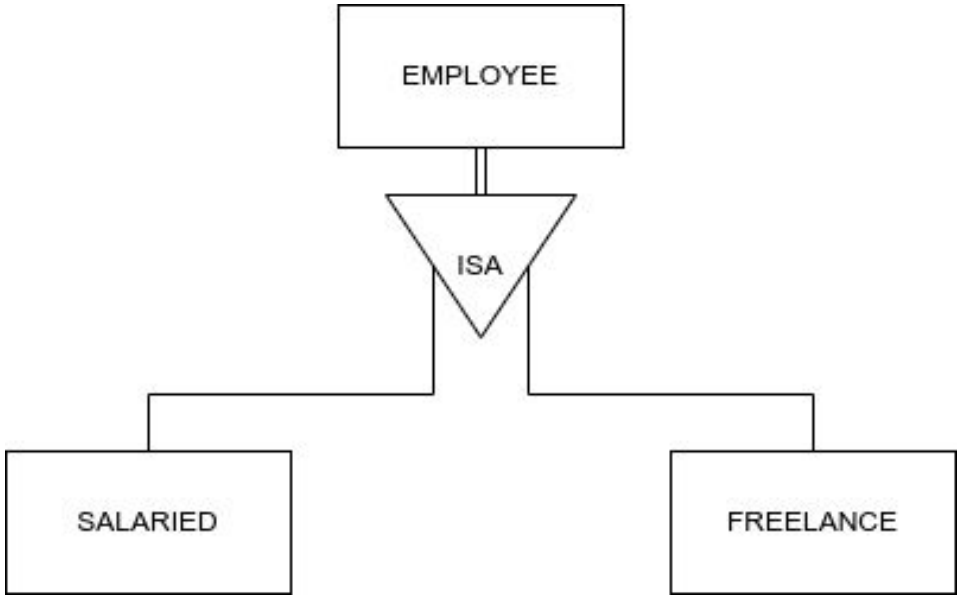
2.8. Subclasses and superclasses.

Total

An employee is salaried or freelance. But all employees are salaried or freelance.



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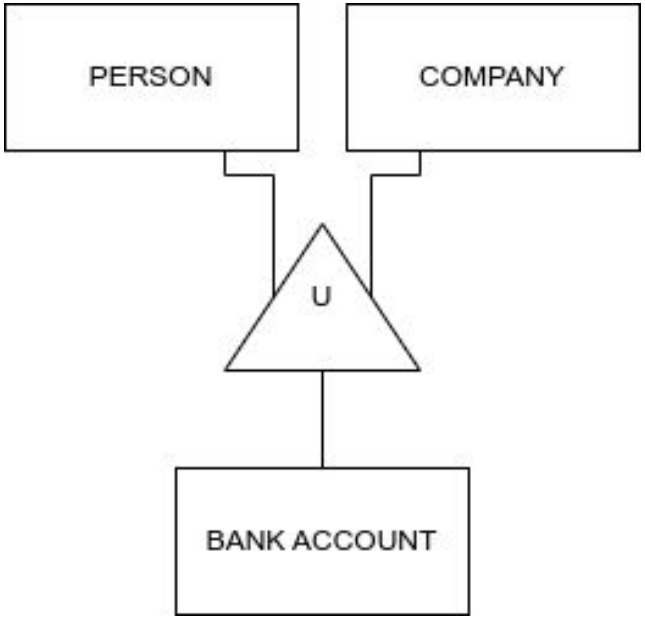
2.8. Subclasses and superclasses.

UNION

People and companies have a bank account.



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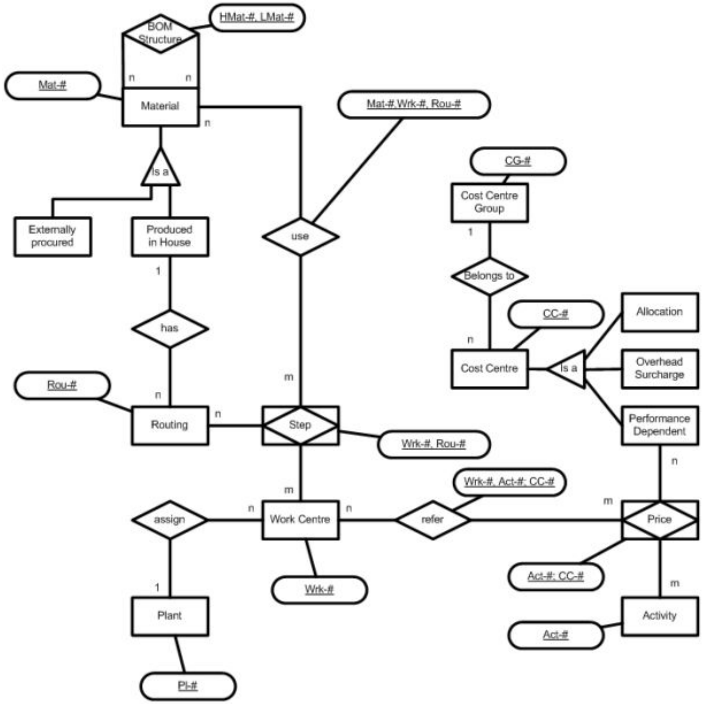
2.8. Subclasses and superclasses.



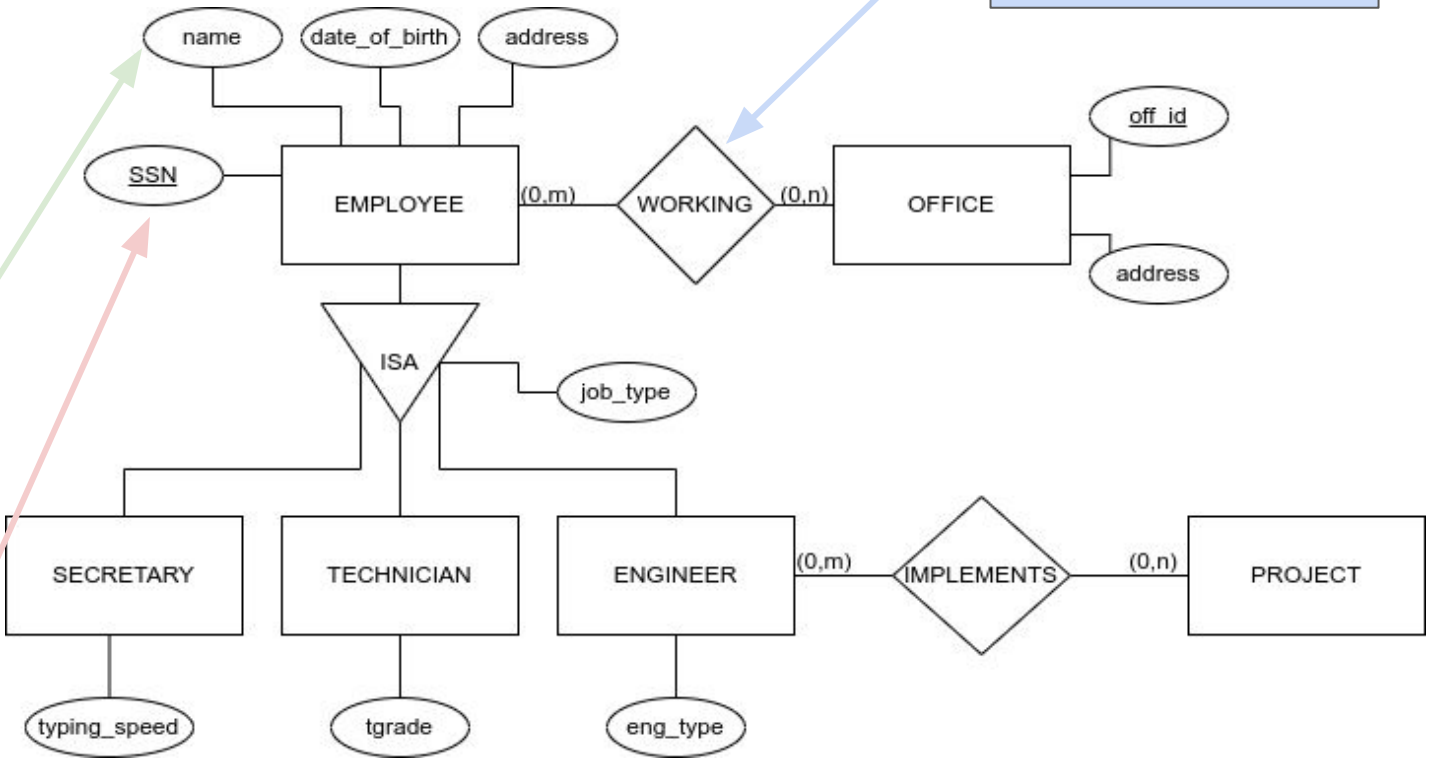
Source https://www.wu.ac.at/fileadmin/wu/o/erp/webtrainer/erm_webtrainer/exercise/pdf/id33_pdf.pdf.

2.8. Enhanced E-R Model. Inheritance.

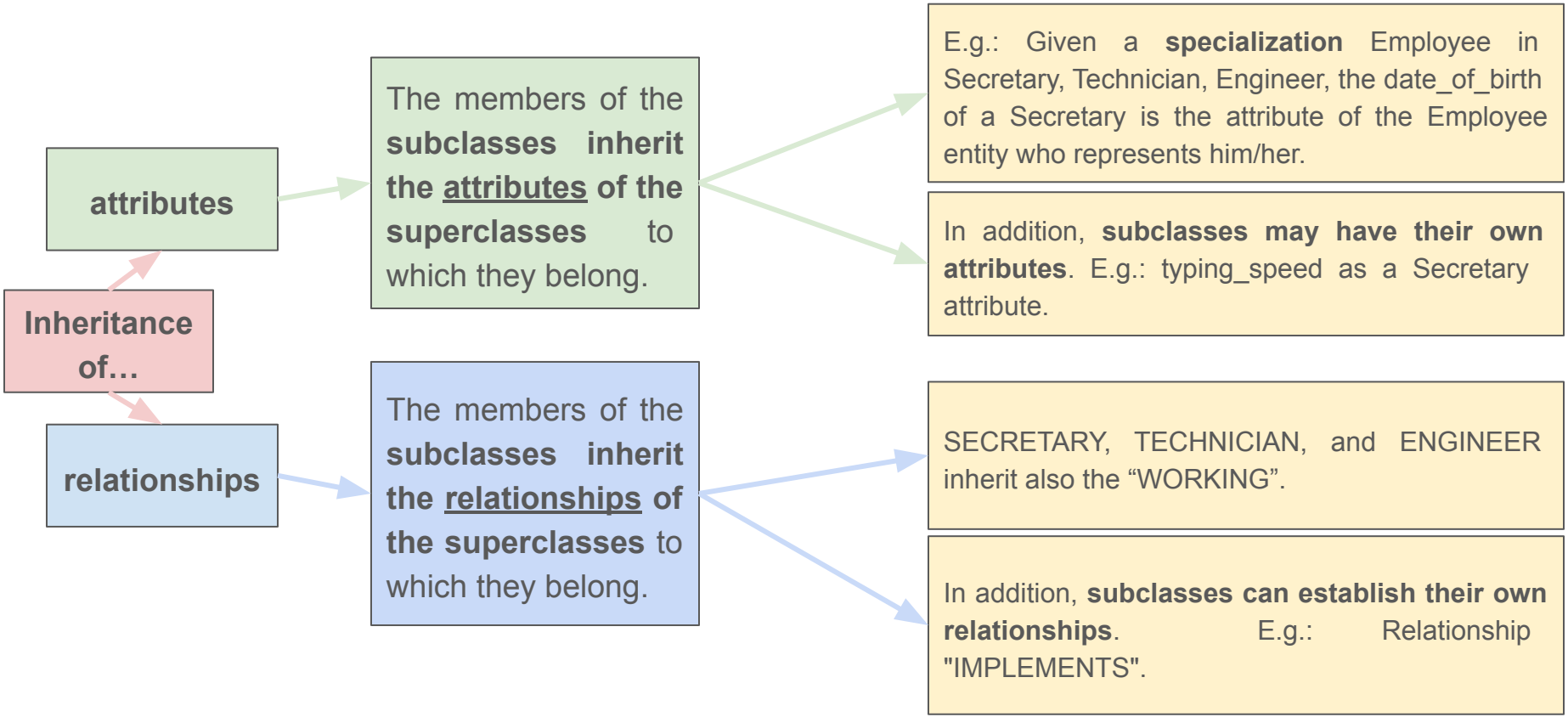
Relationships will also be inherited.

The **other attributes** will also be inherited.

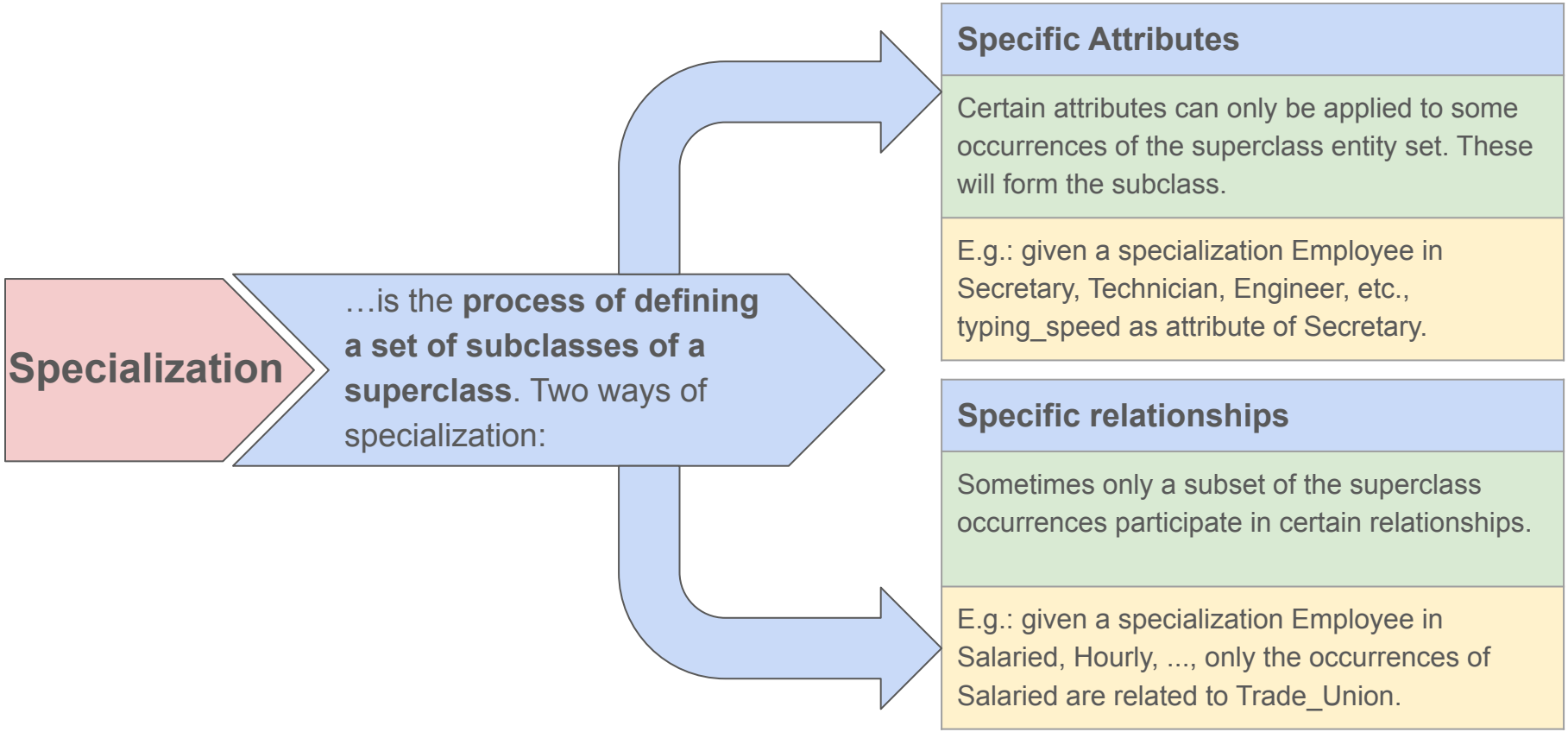
SSN will be the **identifier** for the subentities.



2.8. Enhanced E-R Model. Inheritance.



2.8. Enhanced E-R Model. Specialization.



2.8. Enhanced E-R Model. Generalization.

Generalization

…is the reverse of the specialization process. **Several classes** with common features are **generalized into a superclass**: Original classes become its subclasses.

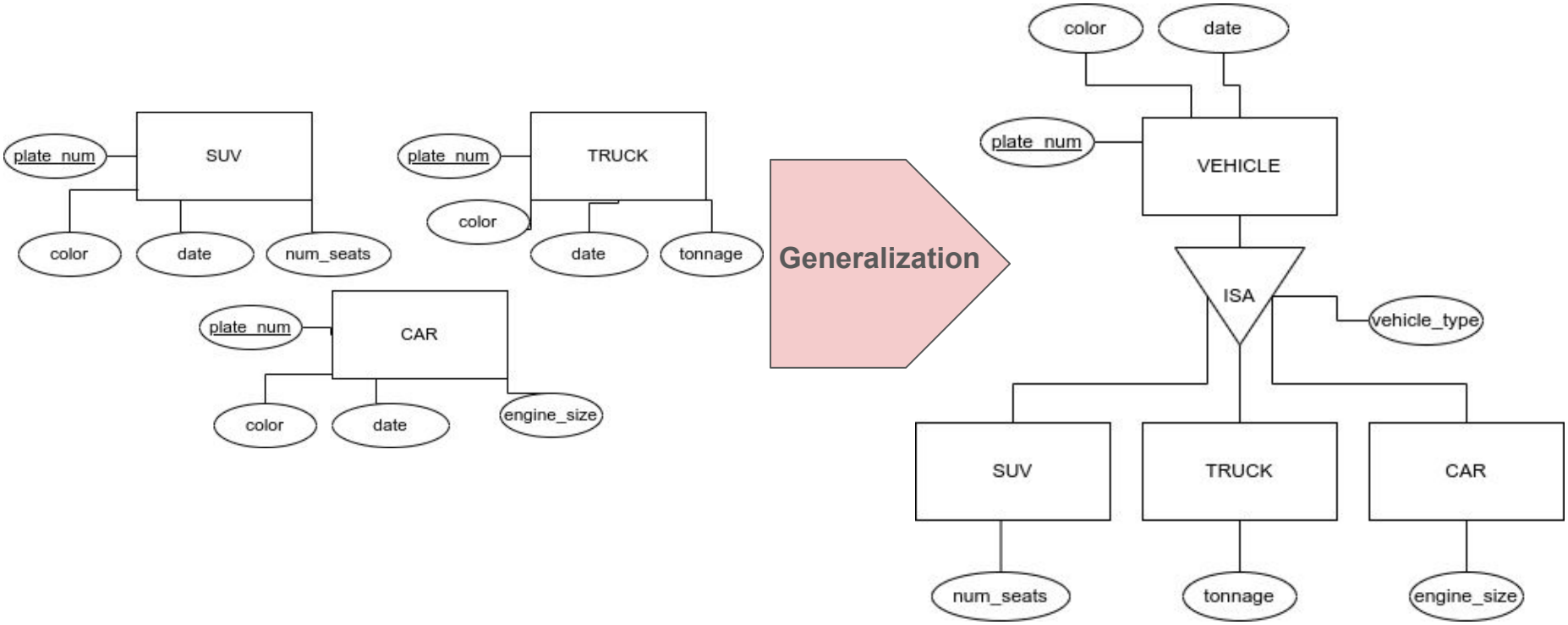
Example: SUV, TRUCK, CAR generalized into VEHICLE.

SUV, TRUCK, and CAR become **subclasses of the superclass VEHICLE**.

We can view **SUV, TRUCK, and CAR** as a **specialization of VEHICLE**.

Alternatively, we can view **VEHICLE** as a **generalization of SUV, TRUCK, and CAR**.

2.8. Enhanced E-R Model. Generalization.



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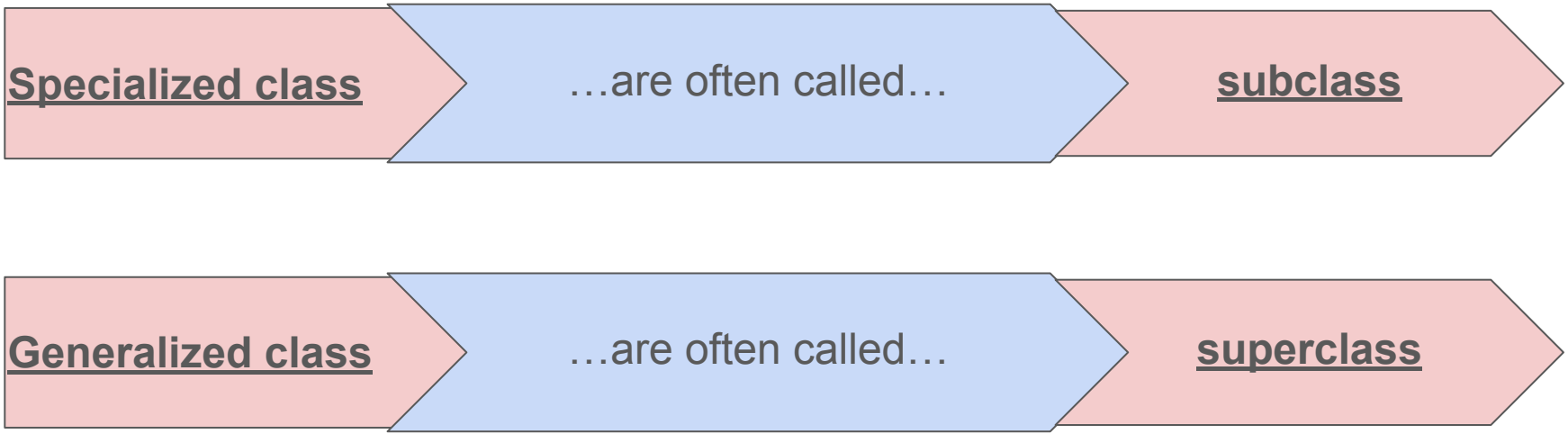
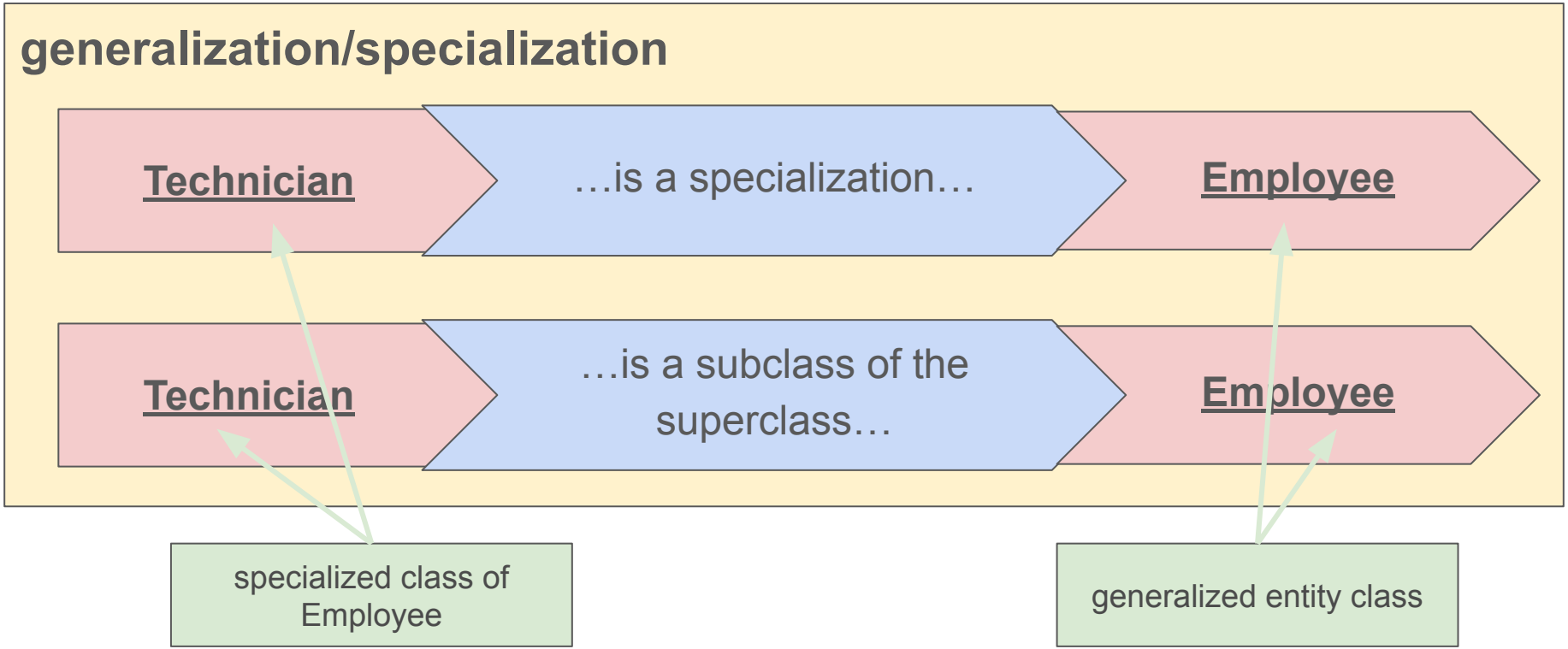
2.8. Enhanced E-R Model. Relation between Specialization/generalization and subclass/superclass.



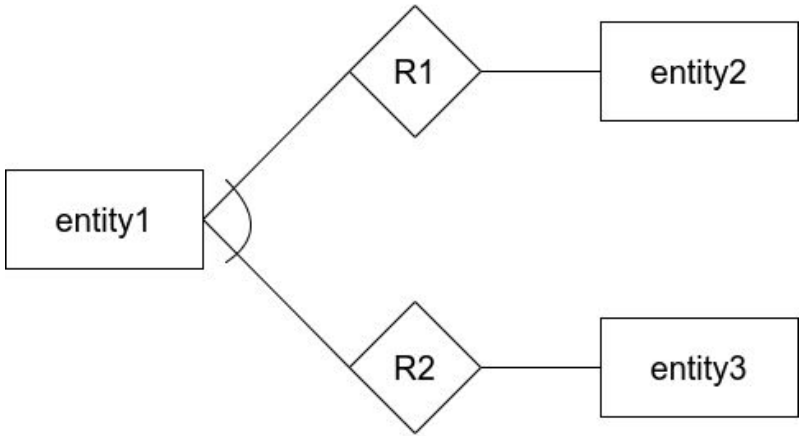
2.8. Enhanced E-R Model. Relation between Specialization/generalization and subclass/superclass.

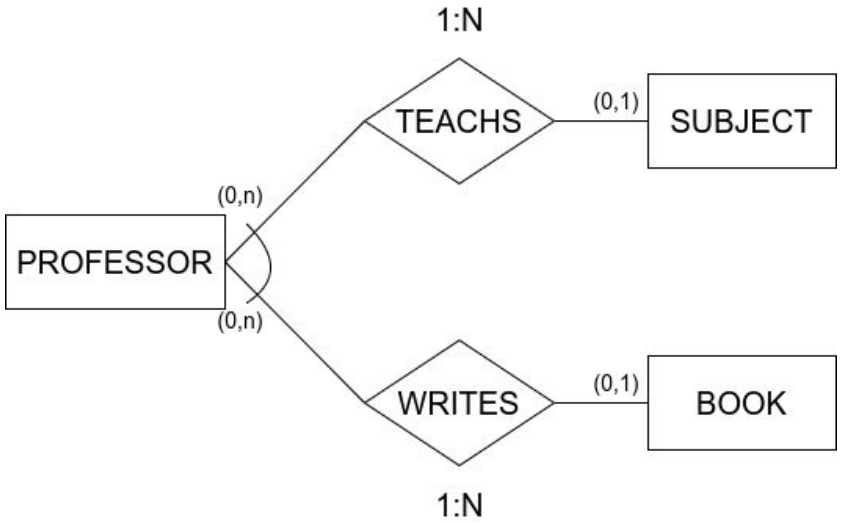


2.8. Enhanced E-R Model. Exclusivity

Exclusivity

Entity1 has a relationship with Entity2 or Entity1 has a relationship with Entity3. But only with one!





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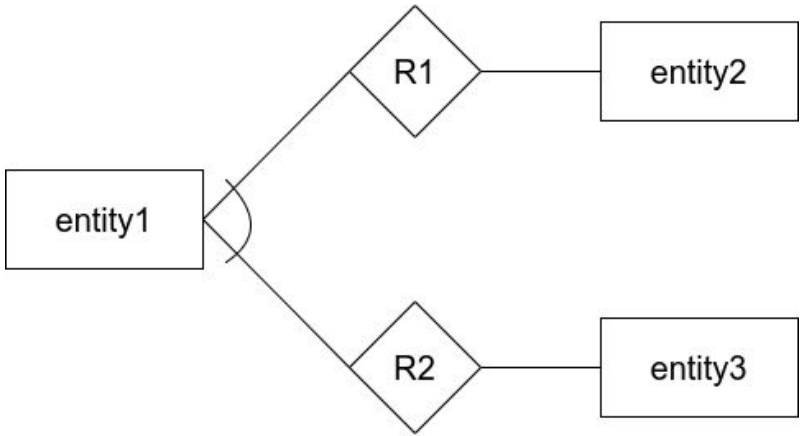
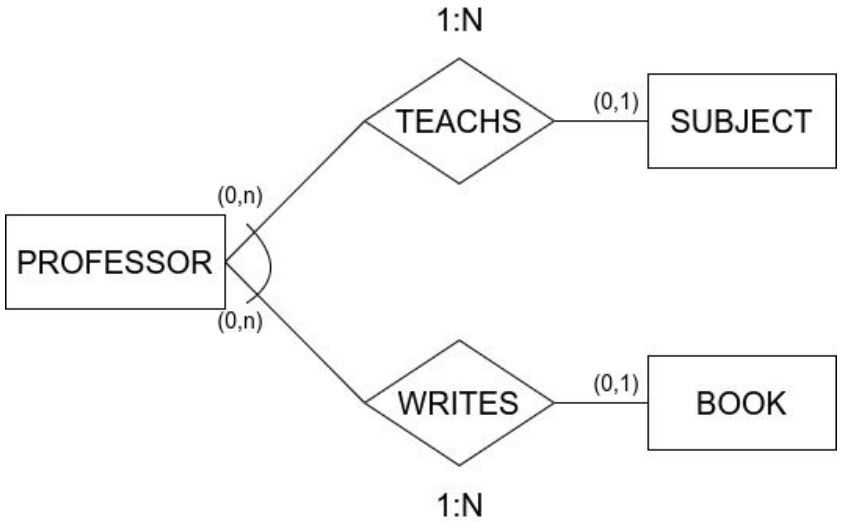
2.8. Enhanced E-R Model. Exclusivity

Exclusivity

Entity1 has a relationship with Entity2 or Entity1 has a relationship with Entity3. But only with one!





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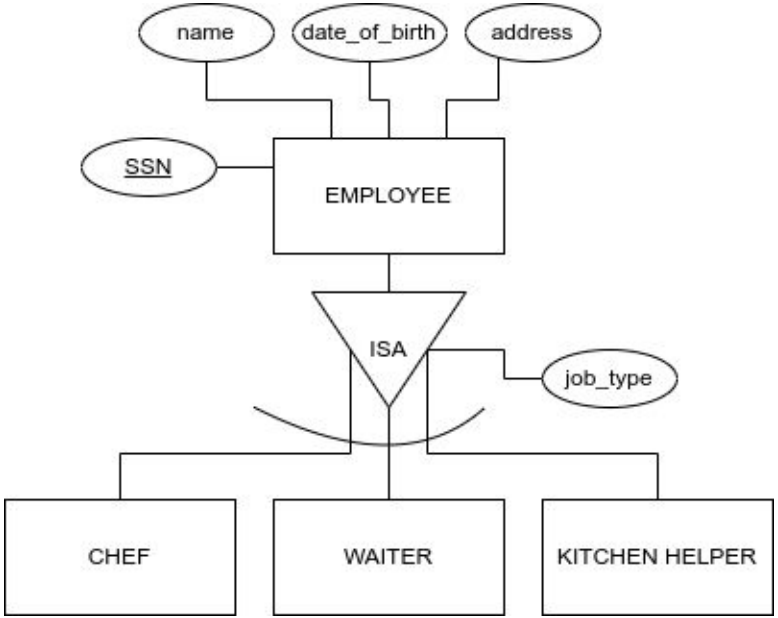
2.8. Enhanced E-R Model. Exclusivity

Exclusivity ??



?

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