

lecture 4: Data Modeling Part III

Main reference:

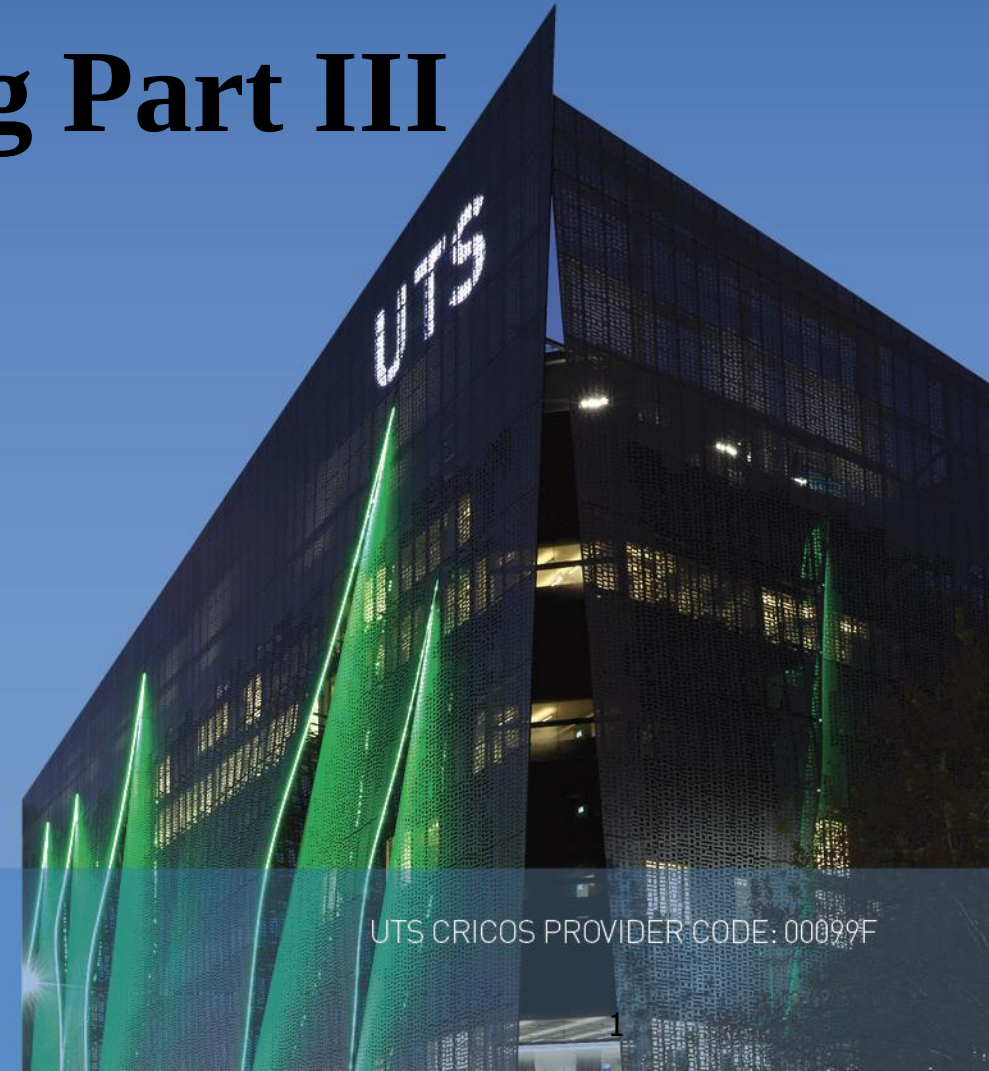
**Modern Database Management, 11th Edition
Chapter 3: The Enhanced E-R Model**

Subject Coordinator and Instructor:

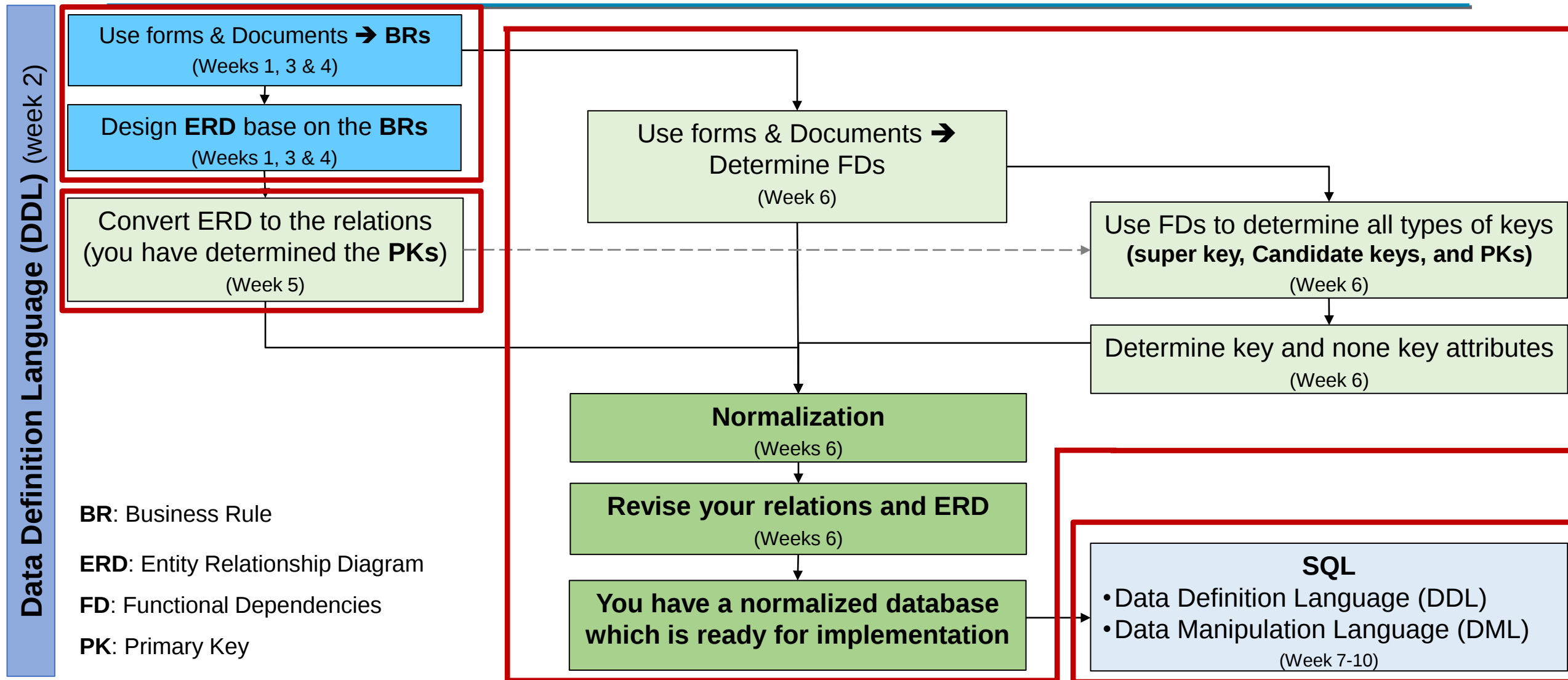
Dr. Danna (Fahimeh) Ramezani

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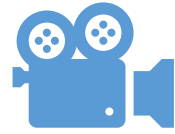
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Subject Flowchart



Subject Overview



➤ Design Entity Relationship Diagram (ERD)

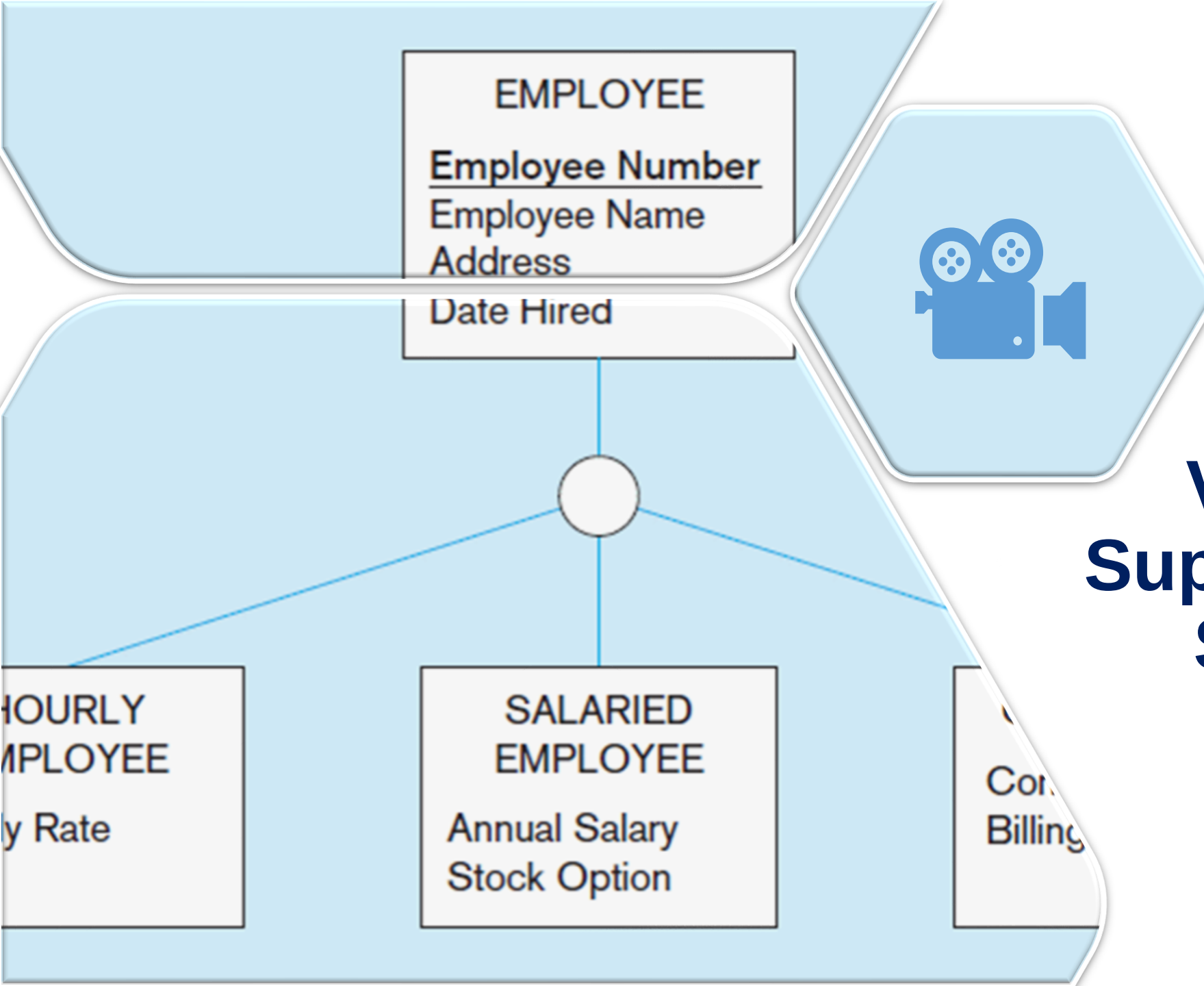
- Week 1: Data Modelling I (Conceptual Level): Entity, Attributes, PK, FK, ...
- Week 2: Data Definition Language (DDL): Create tables, constraints, insert, ...
- Week 3: Data Modelling II (Conceptual Level): Associative, Weak, ...
- **Week 4: Data Modelling III (Conceptual Level): Subtype/Supertype**
- Week 5: Convert ERD to Relations (Logical Level)
- Week 6: Functional Dependencies, and Normalization

➤ Data manipulation

- Week 7: Simple Query
- Week 8: Multiple Table Queries
- Week 9: Subquery
- Week 10: Correlated Subquery

Objectives

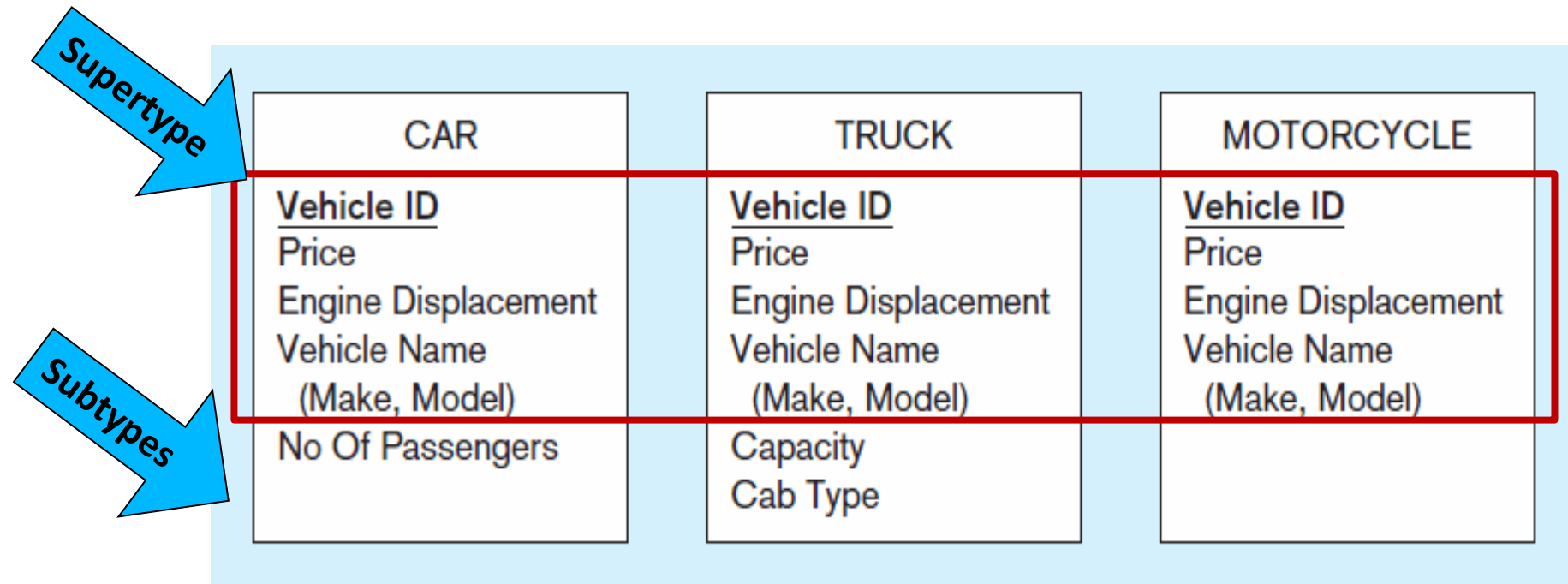
- 1. Supertype/Subtype Relationships**
- 2. Relationships and Subtypes**
- 3. Generalization and Specialization**
- 4. Constraints in Supertype/Subtype Relationships**
 - 4.1. Completeness Constraints (Total or Partial Specialization)
 - 4.2. Disjointness Constraints (Disjoint or Overlapping sub-types)
 - 4.3. Subtype Discriminator



Video 3.1: Supertypes and Subtypes

1. Supertypes and Subtypes

Three **entity types**: **CAR**, **TRUCK**, and **MOTORCYCLE**



All these types of vehicles have the **same entity type**. They have **common attributes** ... some of them they also have **specific attribute(s)**

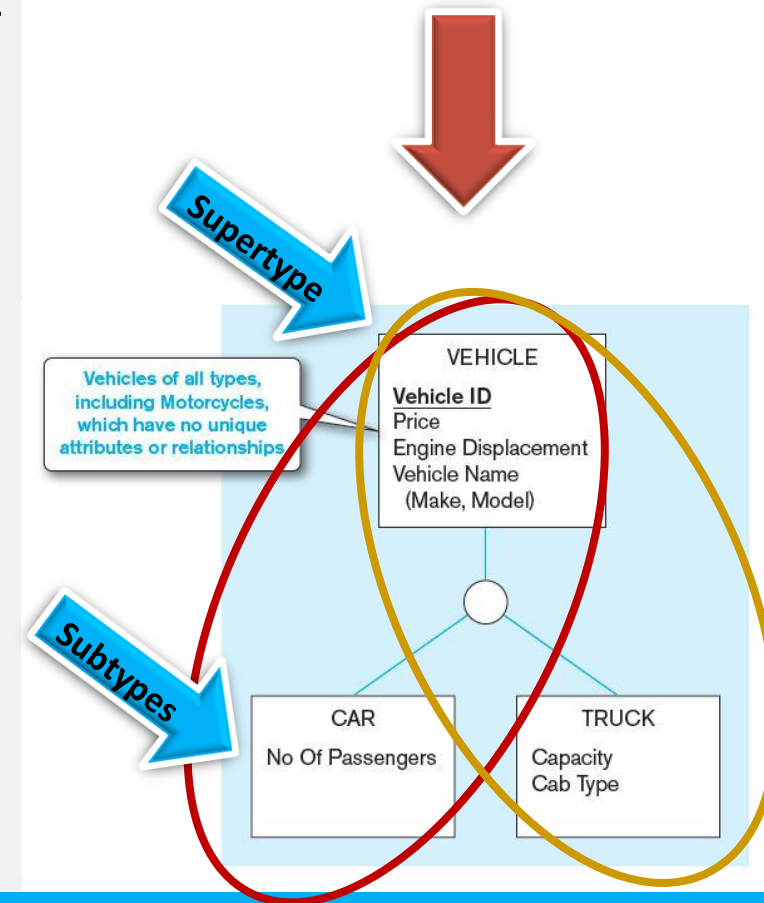
1. Supertypes and Subtypes

Enhanced ER model by extending the original ER model with new modeling constructs using:

- **Subtype:** A **subgroup** of entities **in an entity type** that has **attribute(s)** and/or **relationship(s)** **distinct** from other subgroups.
- **Supertype:** A **generic entity type** that has a relationship with one or more subtypes and has the **common** attributes between the subtypes.
- **Attribute Inheritance:**
 - Subtype entities **inherit** values of all attributes of the supertype.
 - An **instance** of a subtype **is also an instance** of the supertype.

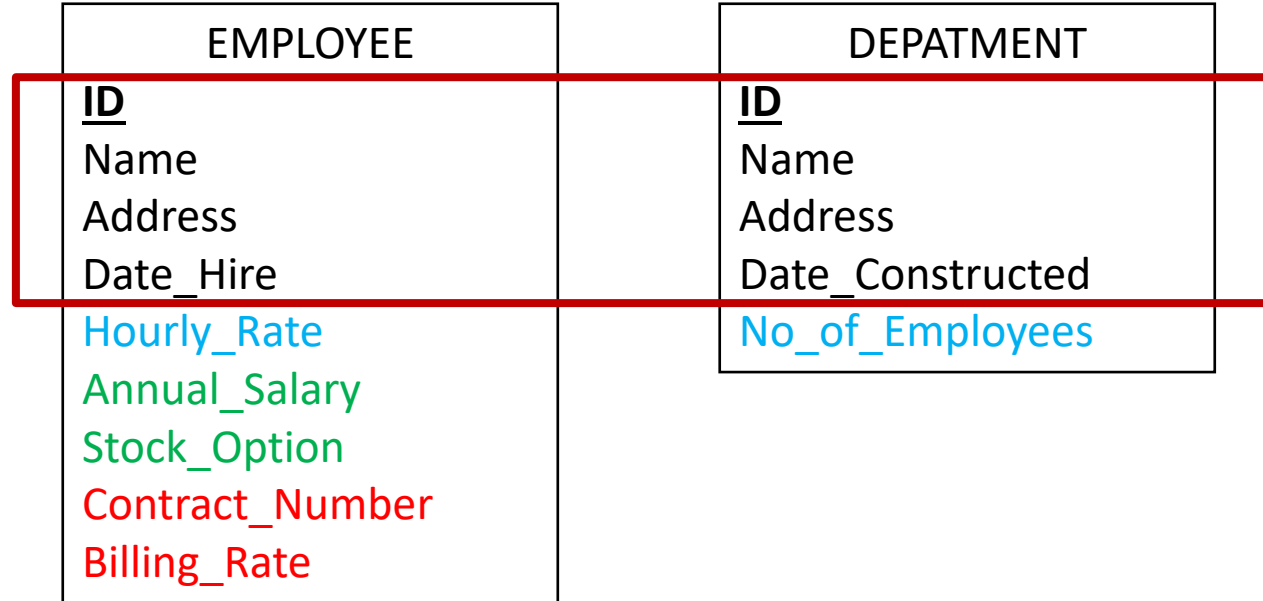
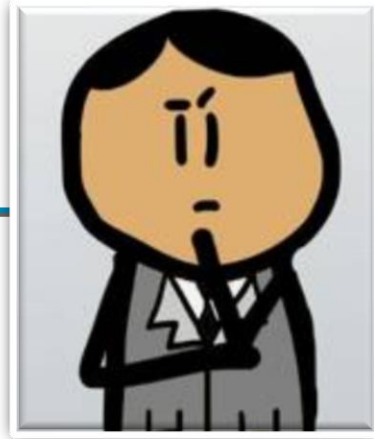
Note: Supertype and its Subtypes have the **same Entity Type**.

CAR	TRUCK	MOTORCYCLE
<u>Vehicle ID</u>	<u>Vehicle ID</u>	<u>Vehicle ID</u>
Price	Price	Price
Engine Displacement	Engine Displacement	Engine Displacement
Vehicle Name (Make, Model)	Vehicle Name (Make, Model)	Vehicle Name (Make, Model)
No Of Passengers	Capacity Cab Type	



(Figure 3-4)

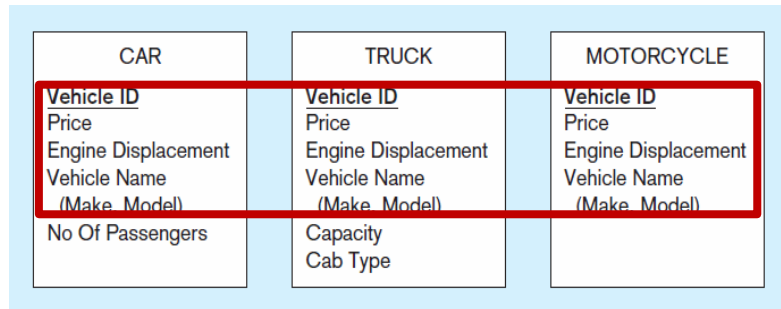
Can I create supertype/subtype design for any group of entities with common attributes?



No ... because these entities **do not have the** same Entity Type

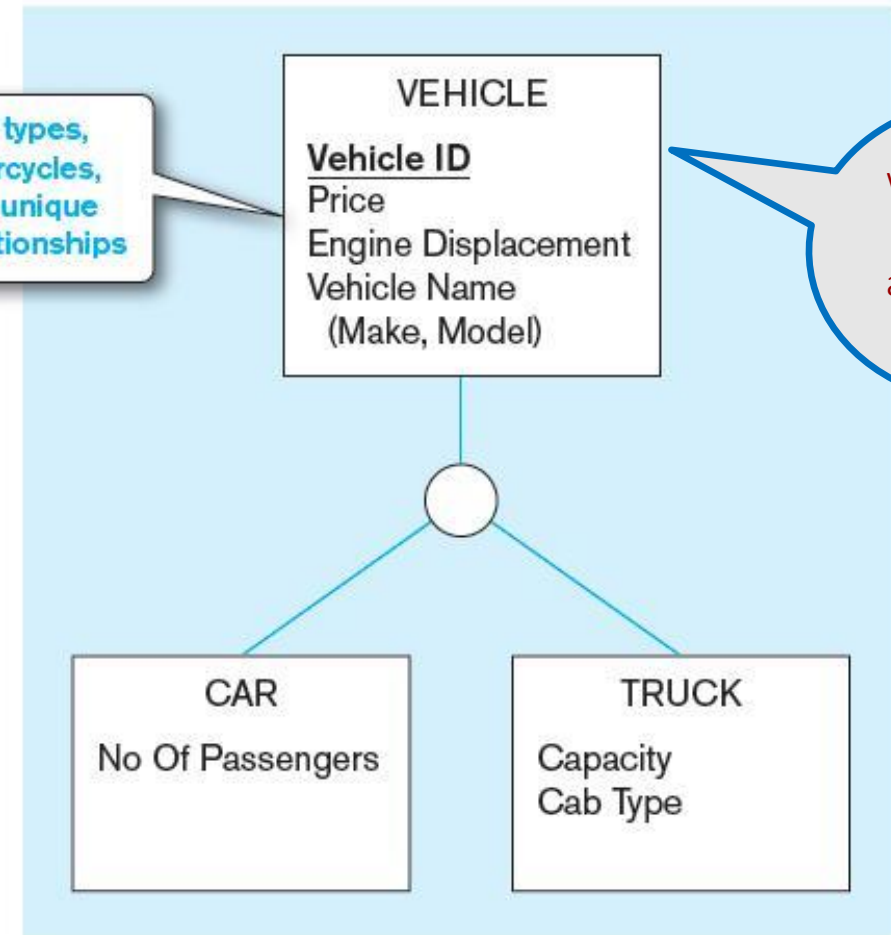


Do we have a subtype for each sub-group of the entity?



Vehicles of all types,
including Motorcycles,
which have no unique
attributes or relationships

Note: no subtype for **motorcycle**,
since it has no specific **attributes**
or **relationship**.



we have the
common
attributes in
a **supertype**



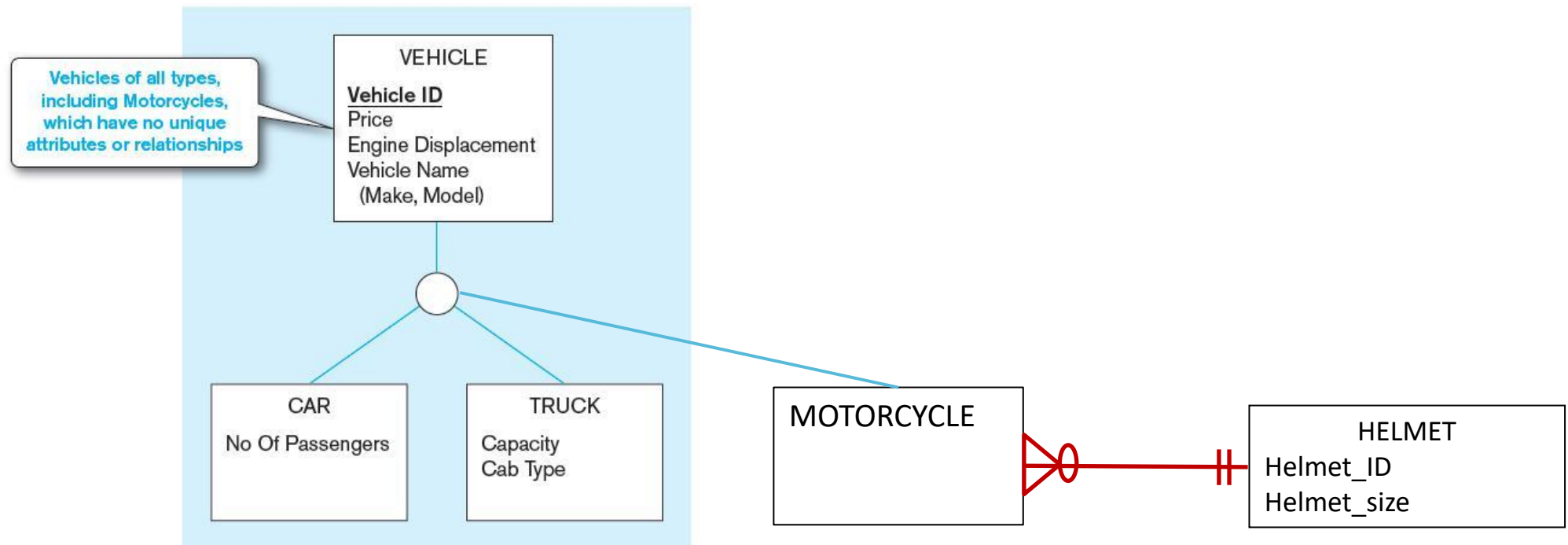
Do we have a subtype for each sub-group of the entity?

CAR	TRUCK	MOTORCYCLE
<u>Vehicle ID</u> Price Engine Displacement Vehicle Name (Make, Model) No Of Passengers	<u>Vehicle ID</u> Price Engine Displacement Vehicle Name (Make, Model) Capacity Cab Type	<u>Vehicle ID</u> Price Engine Displacement Vehicle Name (Make, Model)

Note: There was no subtype for **motorcycle**, since it has no unique **attributes** ...

Question: what if **motorcycle** participate in a **specific relationship**?

BR: Every helmet can be chosen for any motorcycle, and every motorcycle needs to have an allocated helmet.



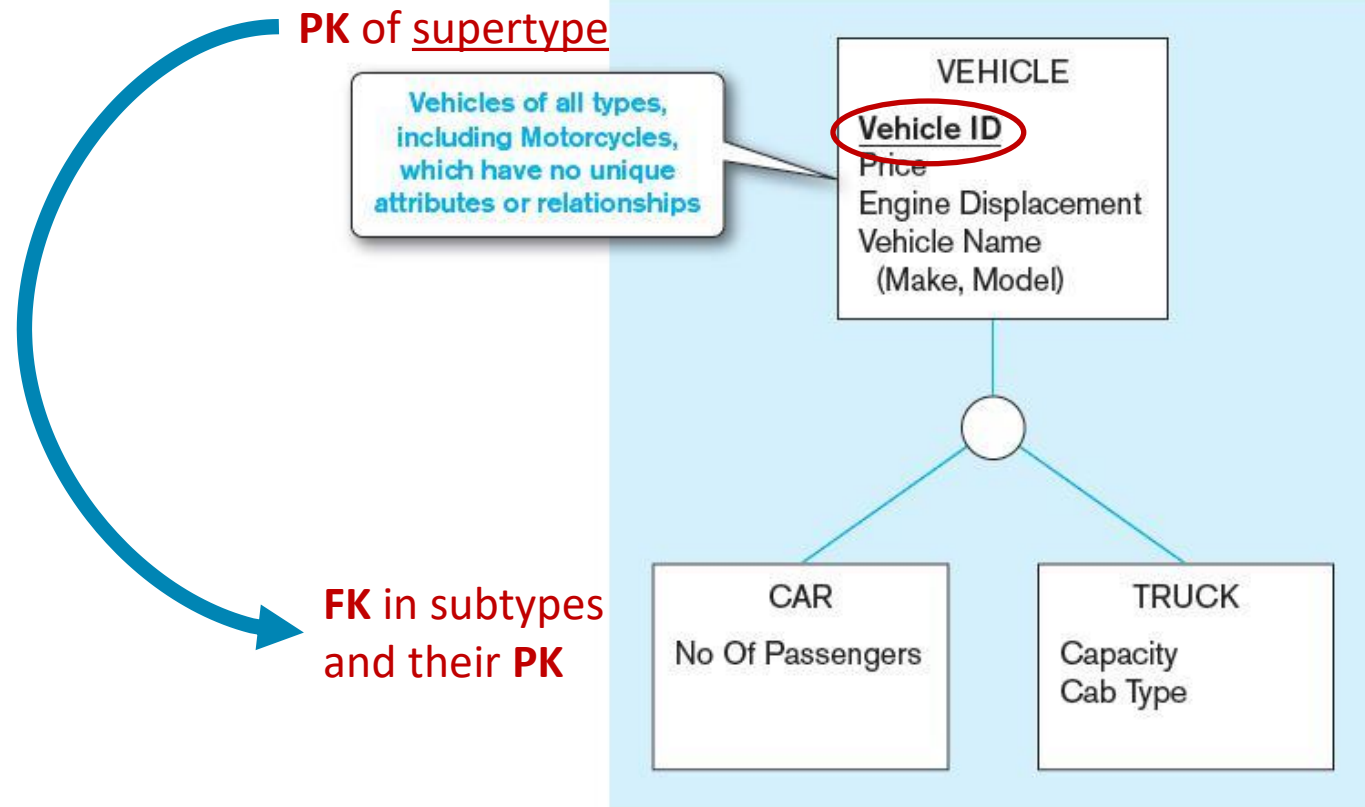
Note: We need to create a subtype for each sub-group of the entity IF that sub-group has **specific attributes** and/or **specific relationship**.



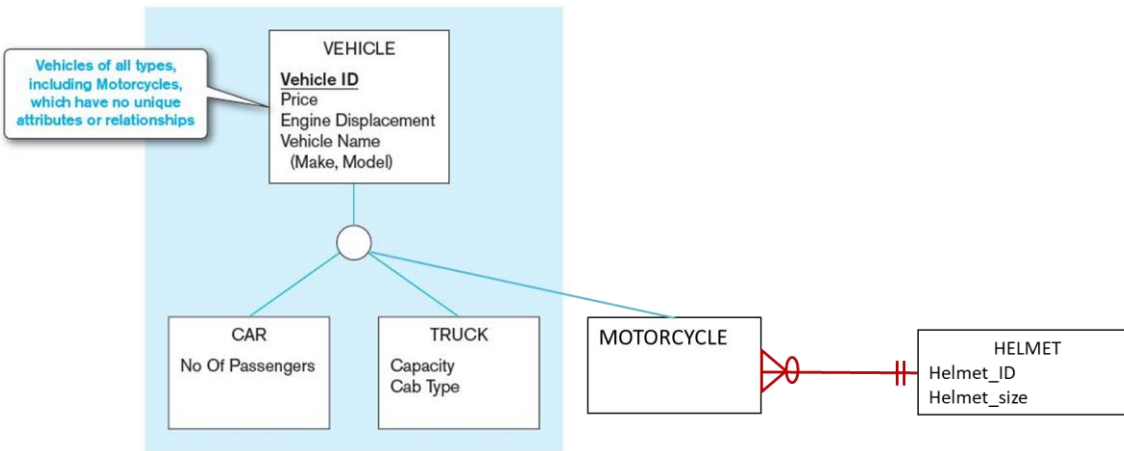
PK and FK of Supertype and its Subtypes

- **PK** of supertype is **FK** in each subtype.
- This **FK** is also the **PK** of the subtypes.

CAR	TRUCK	MOTORCYCLE
<u>Vehicle ID</u>	<u>Vehicle ID</u>	<u>Vehicle ID</u>
Price	Price	Price
Engine Displacement	Engine Displacement	Engine Displacement
Vehicle Name (Make, Model)	Vehicle Name (Make, Model)	Vehicle Name (Make, Model)
No Of Passengers	Capacity Cab Type	



Note: no subtype for **motorcycle**, since it has no unique attribute or relationship.

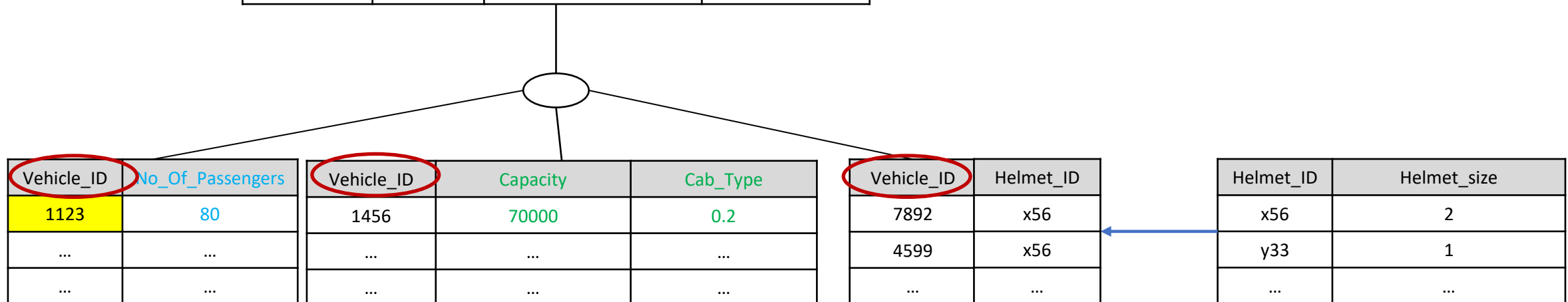


- **PK of supertype is FK in each subtype**
- This FK is **PK** of the subtypes

Attribute Inheritance:

- Subtype entities **inherit** values of all attributes of the supertype
- An **instance** of a subtype **is also an instance** of the supertype

Vehicle_ID	Price	Engine_Displacement	Vehicle_Name
1123	15000	...	...
1456	24000	...	...
7892	60000	...	...
...	...	...	...





Class Activity 4.1: Discussion (10 Minutes) → in the live lecture

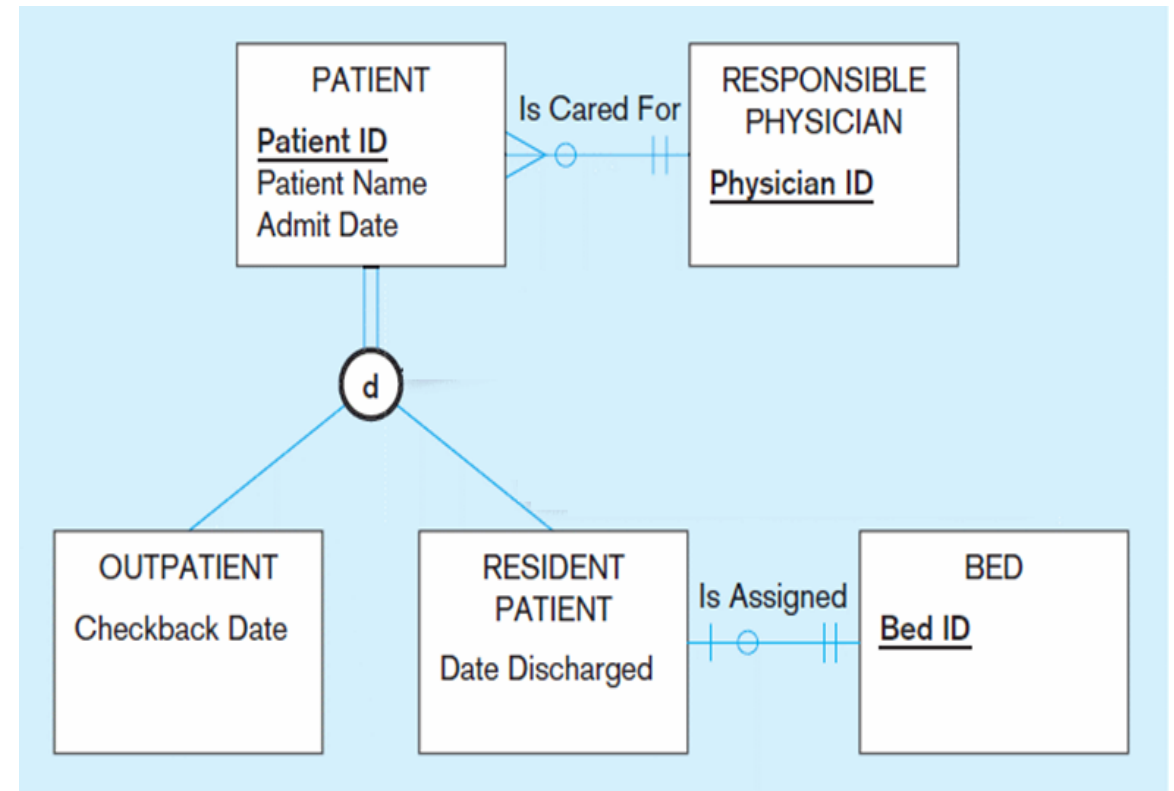
- Introduce another example for Supertypes and Subtypes.
- What the following definitions mean:
 - Subtype entities **inherit** values of all attributes of the supertype
 - An **instance** of a subtype **is also an instance** of the supertype
 - **Supertype** and its **Subtypes** have the **Same Entity Type**.



Class Activity 4.2 (2 Minutes) → in the live lecture

1. In the figure below, which of the following apply to both OUTPATIENTS and RESIDENT_PATIENTS?

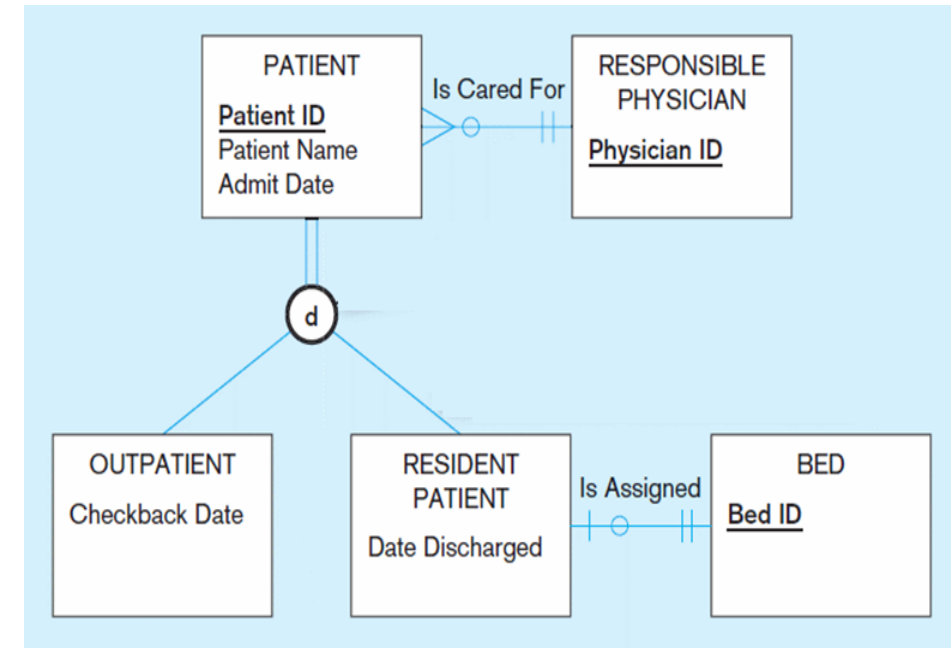
- A. Checkback_D
- B. Date_Discharged
- C. Bed_ID
- D. Patient_ID

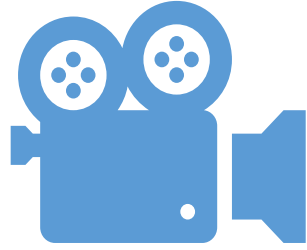




Class Activity 4.3 (5 Minutes) → in the live lecture

Create tables in excel or word for PATIENT, OUTPATIENTs, and RESIDENT_PATIENTs to show how we store data in these tables.

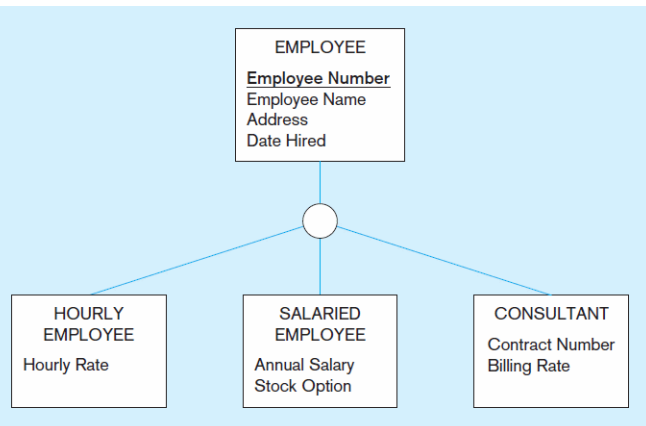




Video 3.2:
Why we need to construct
supertype and subtypes?



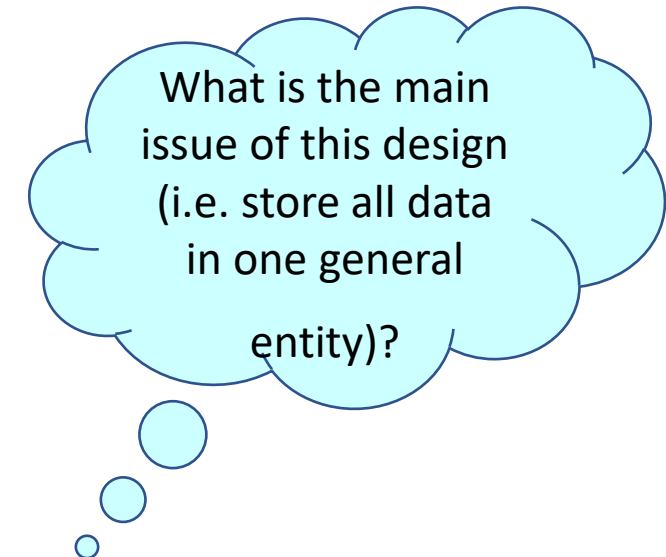
Why we need to construct supertype and subtypes?



Hourly Employee

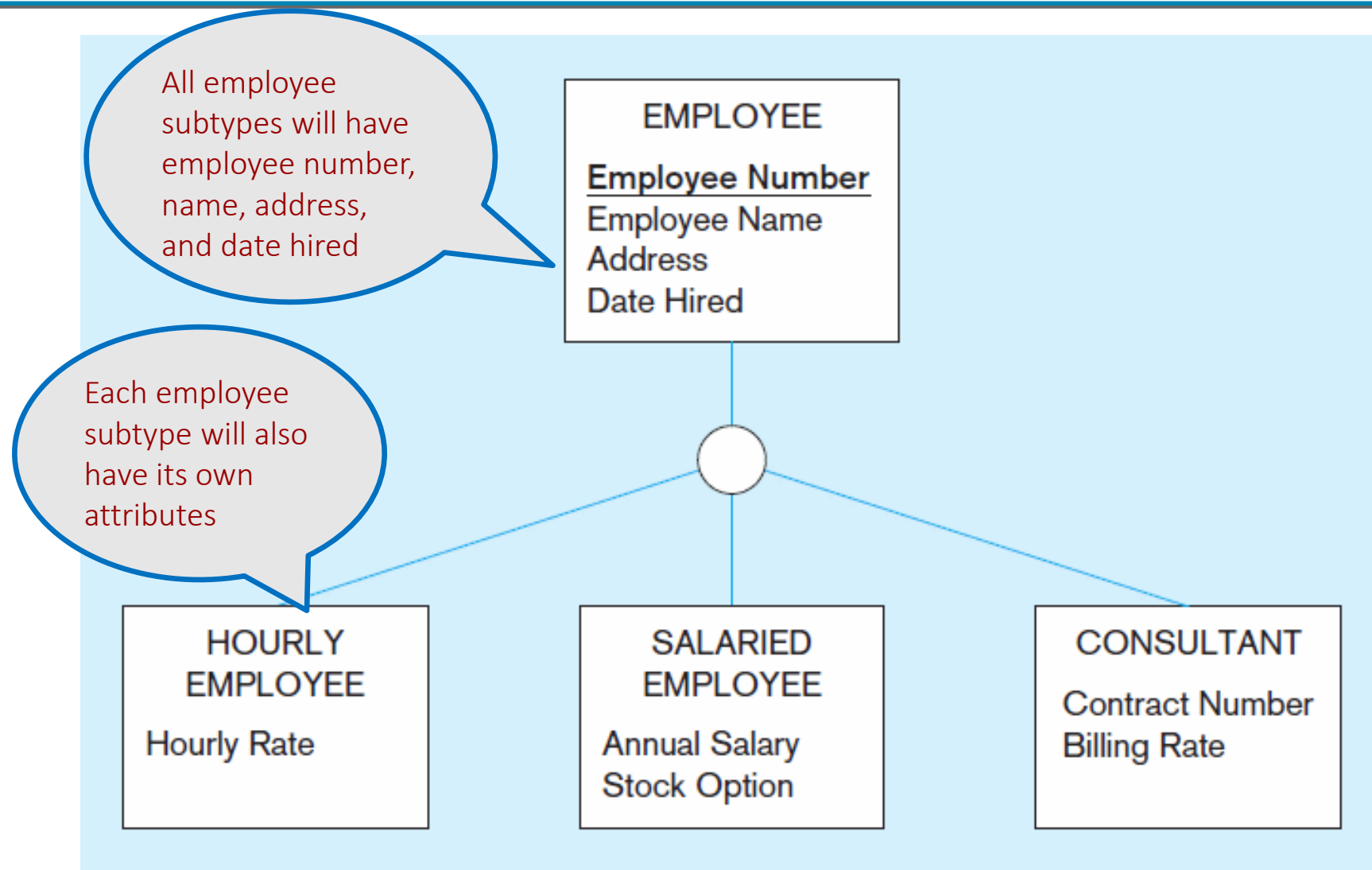
Salaried Employee

Consultant



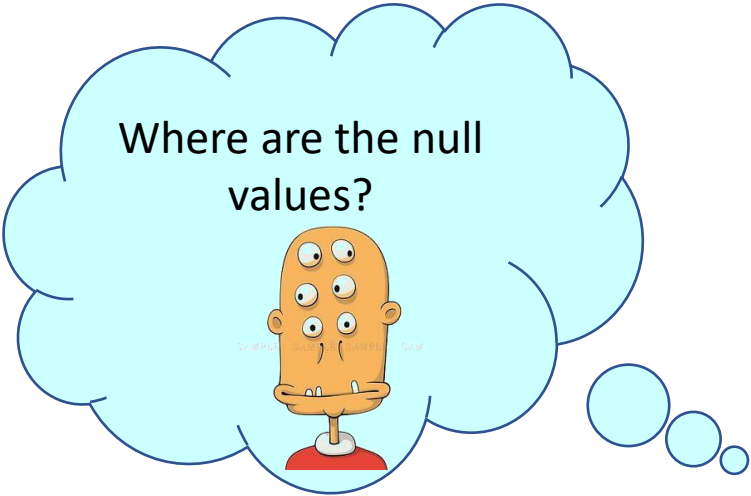
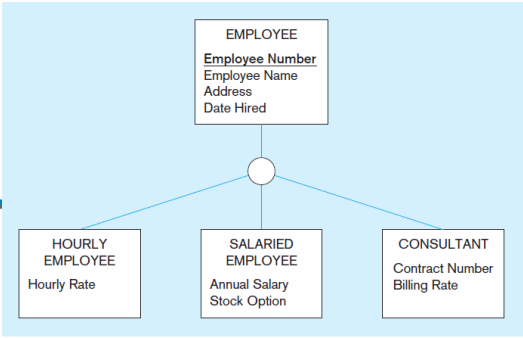
Employee_Number	Employee_Name	Address	Date_Hire	Hourly_Rate	Annual_Salary	Stock_Option	Contract_Number	Billing_Rate
1123	Sara	UTS	1/1/2014	80	null	null	null	null
1456	Jake	32/50 ...	5/8/2013	null	70000	0.2	null	null
7892	Fahimeh	12/97 ...	2/3/2013	null	null	null	9856	50

Employee supertype with three subtypes (Figure 3-2)

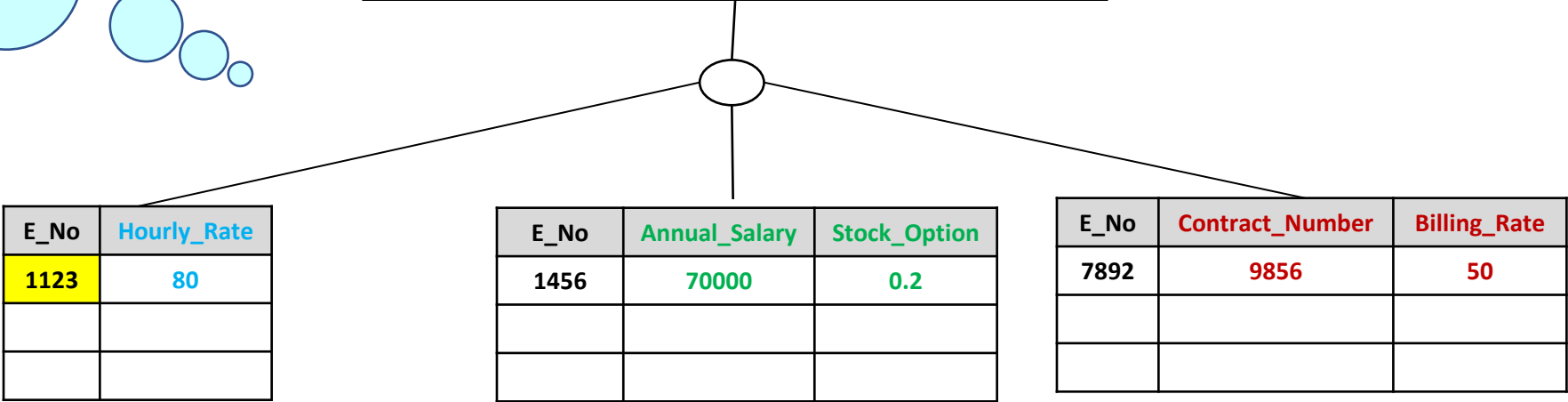


EMPLOYEE
<u>Employee Number</u>
Employee_Name
Address
Date_Hire
Hourly_Rate
Annual_Salary
Stock_Option
Contract_Number
Billing_Rate

Why we need to construct supertype and subtypes? (cont.)



Employee_Number	Employee_Name	Address	Date_Hire
1123	Sara	UTS	1/1/2014
1456	Jake	32/50 ...	5/8/2013
7892	Fahimeh	12/97 ...	2/3/2013

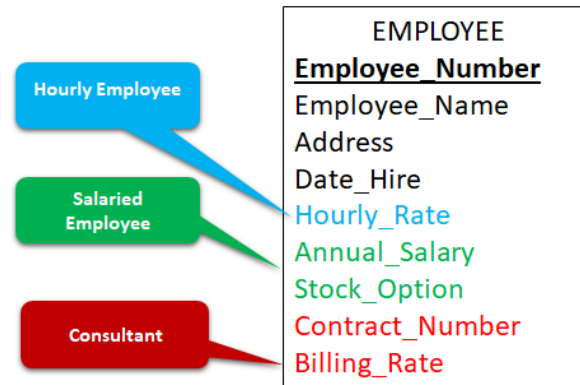


- PK of supertype is FK in each subtype.
- This FK is also the PK of the subtypes.

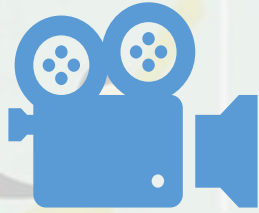


Class Activity 4.4 (6 Minutes) → in the live lecture

For the following employee entity, create the tables for each of the different versions of super/sub type configurations. **How many configurations have you made and is there more?**



Employee_Number	Employee_Name	Address	Date_Hire	Hourly_Rate	Annual_Salary	Stock_Option	Contract_Number	Billing_Rate
1123	Sara	UTS	1/1/2014	80	null	null	null	null
1456	Jake	32/50 ...	5/8/2013	null	70000	0.2	null	null
7892	Fahimeh	12/97 ...	2/3/2013	null	null	null	9856	50

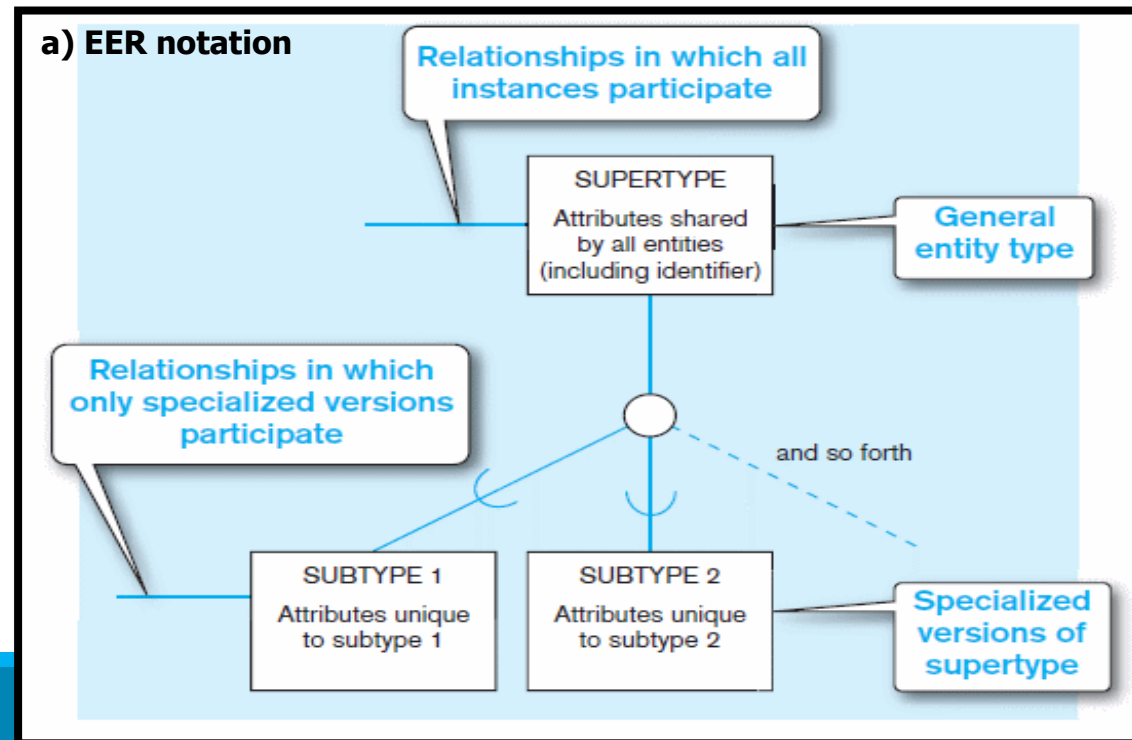


Video 3.3: Relationships and Subtypes



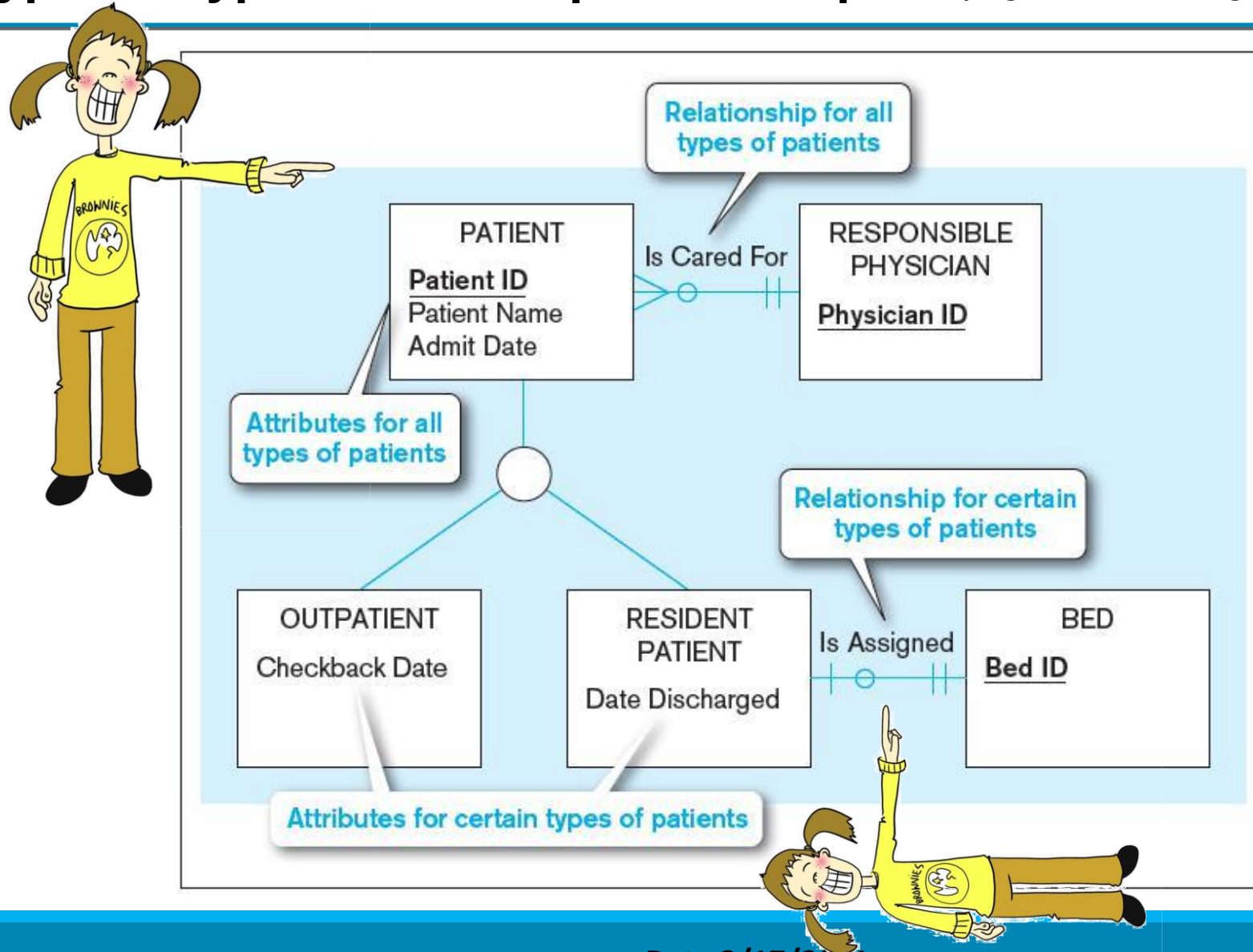
2. Relationships and Subtypes

- If all subtypes will participate in the relationship, then you will have one relationship at the **supertype level**.
- The instances of a **subtype** may participate in a relationship unique to that subtype. In this situation, the relationship is shown at the **subtype level**





Supertype/subtype relationships in a hospital (Figure 3-3 using Entity Relationship Notation)

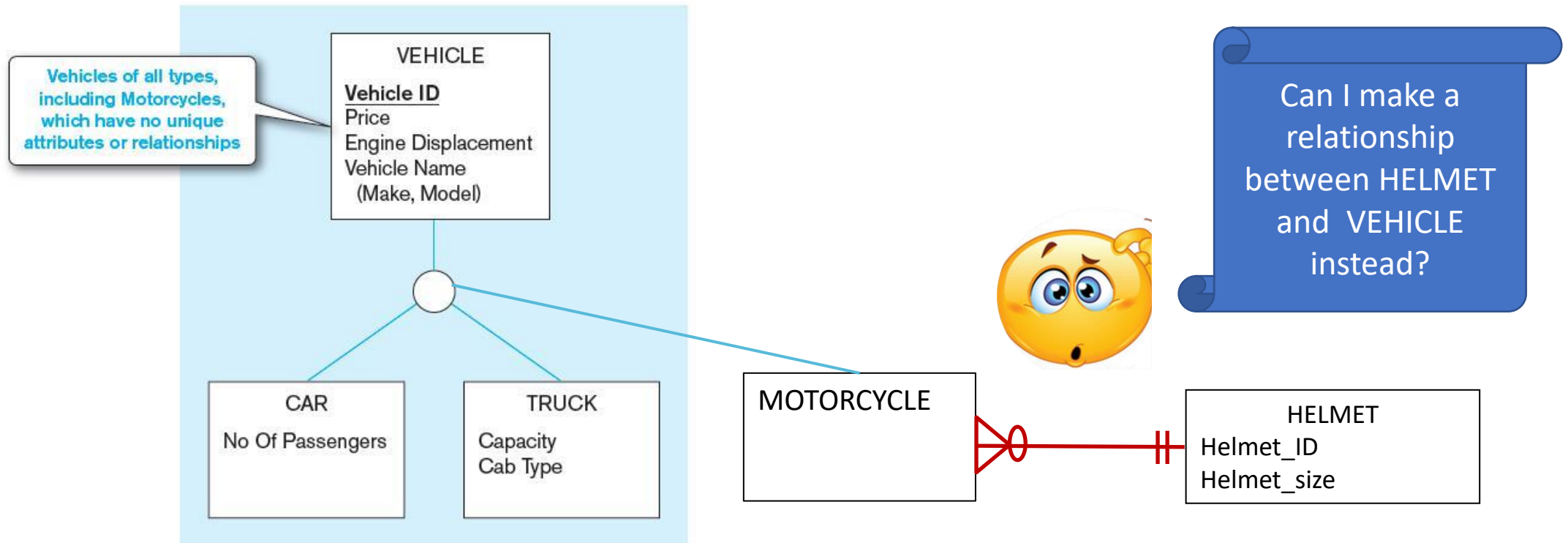




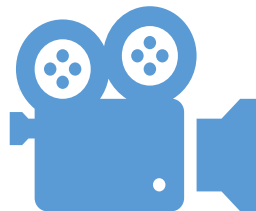
Do we have a subtype for each sub-group of the entity?

CAR	TRUCK	MOTORCYCLE
<u>Vehicle ID</u> Price Engine Displacement Vehicle Name (Make, Model) No Of Passengers	<u>Vehicle ID</u> Price Engine Displacement Vehicle Name (Make, Model) Capacity Cab Type	<u>Vehicle ID</u> Price Engine Displacement Vehicle Name (Make, Model)

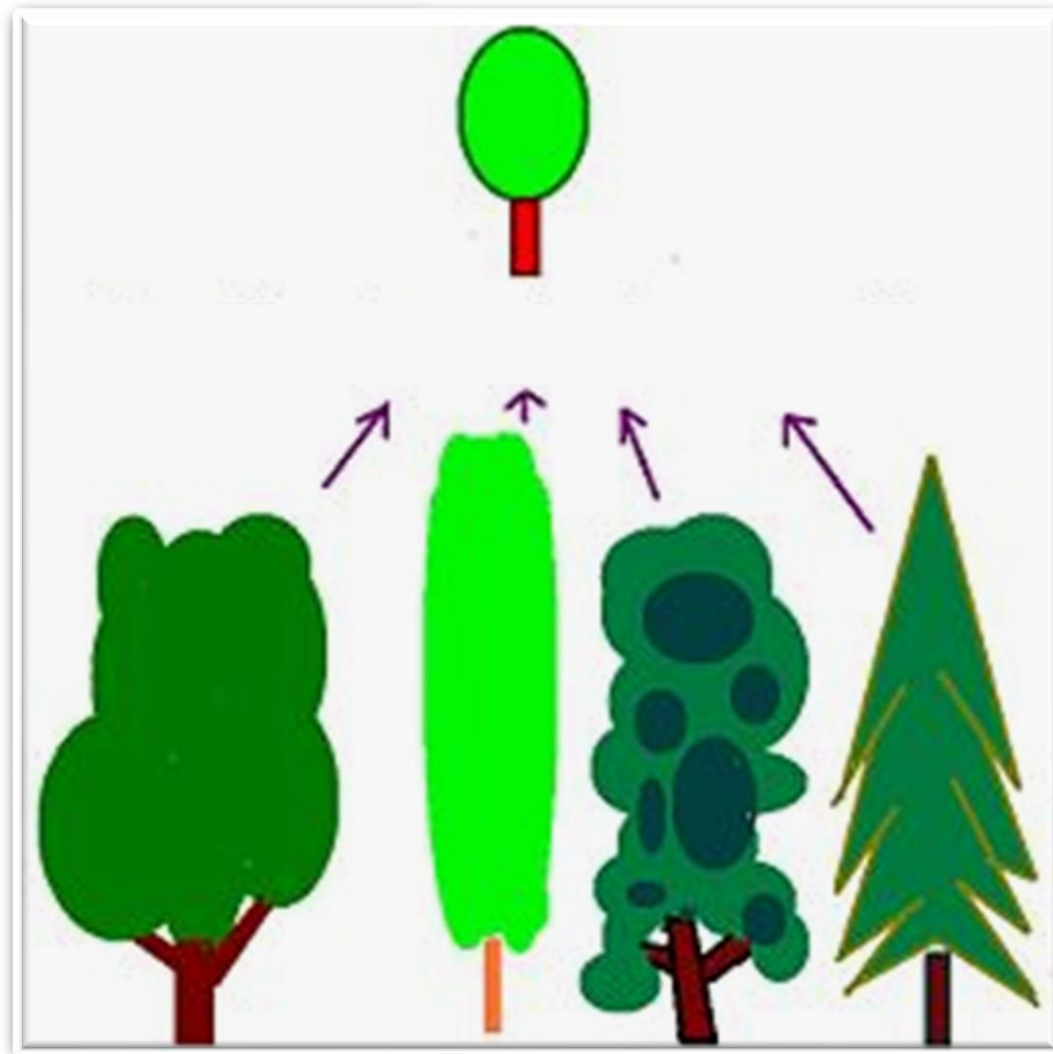
BR: Every helmet can be chosen for any motorcycle, and every motorcycle needs to have an allocated helmet.



Note: We need to create a subtype for each sub-group of the entity IF that sub-group has specific attributes and/or specific relationship.



Video 3.4: Generalization and Specialization

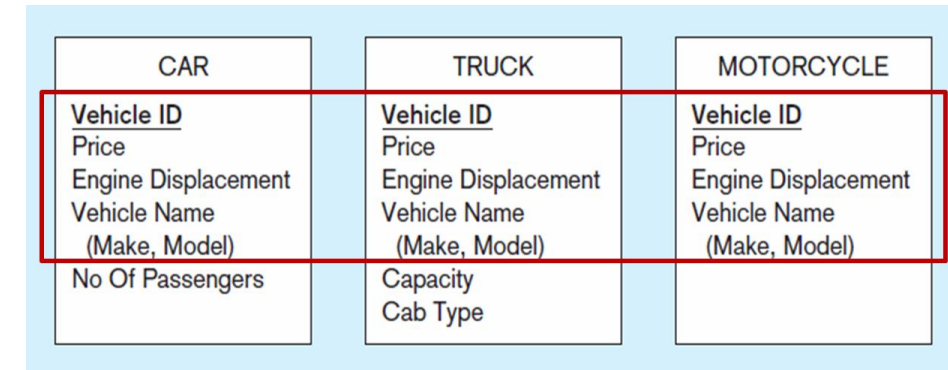




3. Generalization and Specialization

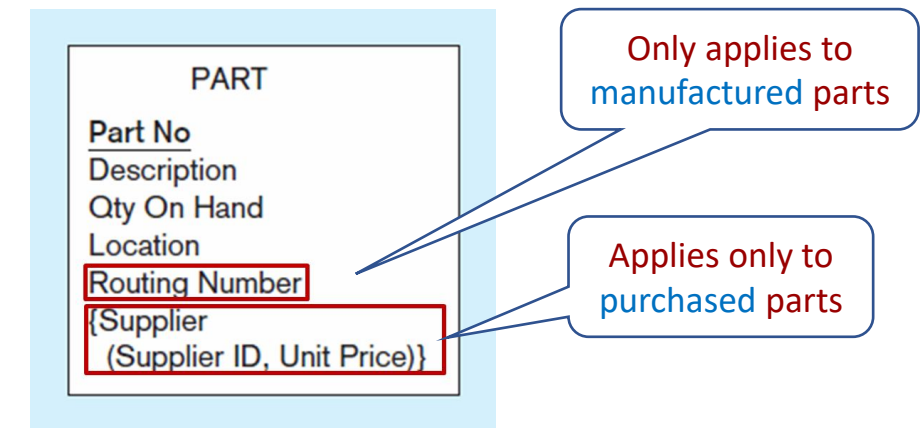
➤ Generalization:

The process of defining a more general entity type from a set of more specialized entity types (BOTTOM-UP).



➤ Specialization:

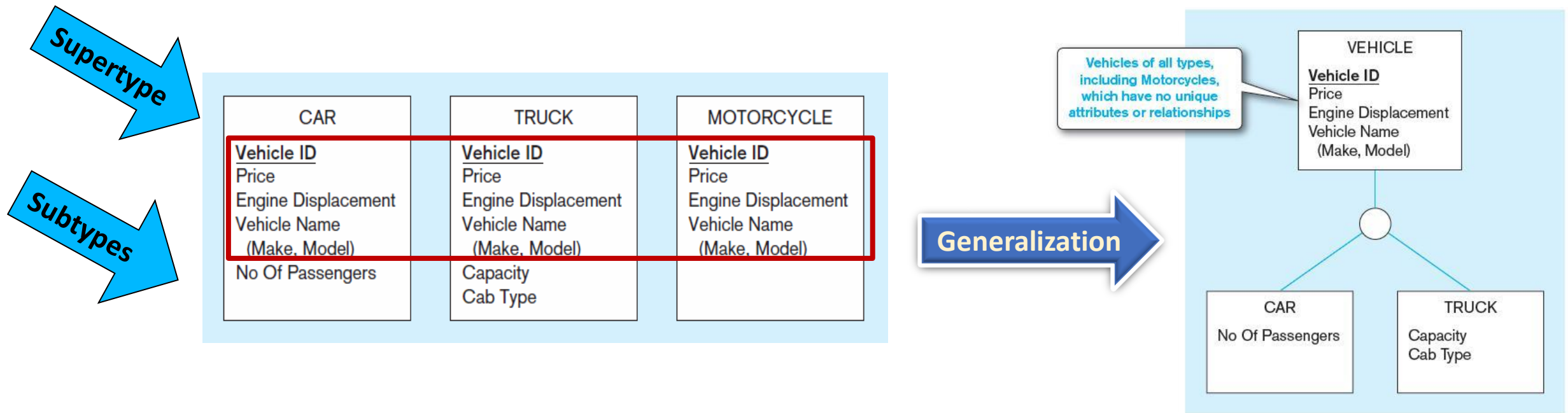
The process of defining one or more subtypes of the supertype and forming supertype/subtype relationships (TOP-DOWN).





Example of generalization (Figure 3-4)

- **Generalization:** The process of defining a more general entity type from a set of more specialized entity types (**BOTTOM-UP**).



Three **entity types**: **CAR**, **TRUCK**, and **MOTORCYCLE**. All these types of vehicles have the same entity type. They have common attributes ... Some of them have also specific attribute(s) ...

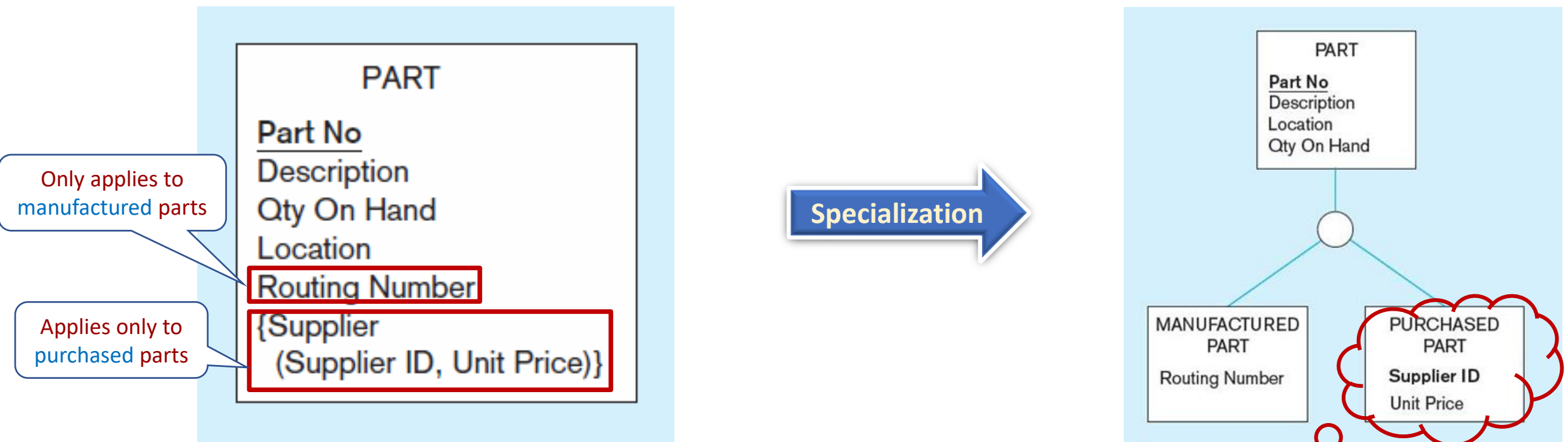
Note: no subtype for **motorcycle**, since it has no unique attributes or relationship.



Example of specialization (Figure 3-5)

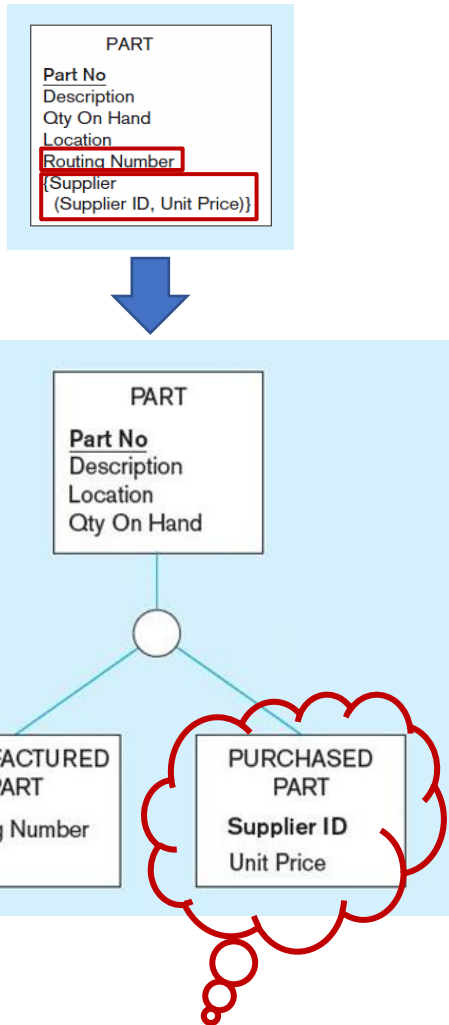
Specialization: The process of defining **one or more subtypes** of the supertype and forming supertype/subtype relationships (**TOP-DOWN**).

PART is specialization to **MANUFACTURED PART** and **PURCHASED PART**



Note: based on the “**BR: Each part can be supplied by many suppliers**” there are **multivalued composite attributes** in this ERD ...

Note: based on the “BR: Each part can be supplied by many suppliers” there are multivalued composite attributes in this ERD ...



Let's draw the table correspond to the “**Purchased Part**” subtype where the following transactions are done at **the same time**:

- Part 12w is supplied by two suppliers with IDs 6695 and 2095
- Part 13a is supplied by two suppliers with IDs 4547 and 6695 suppliers

PURCHASED PART

Part No	Supplier ID	Unit Price
12w	6695, 2095	80, 50
13a	4547, 6695	60, 60

X

PURCHASED PART

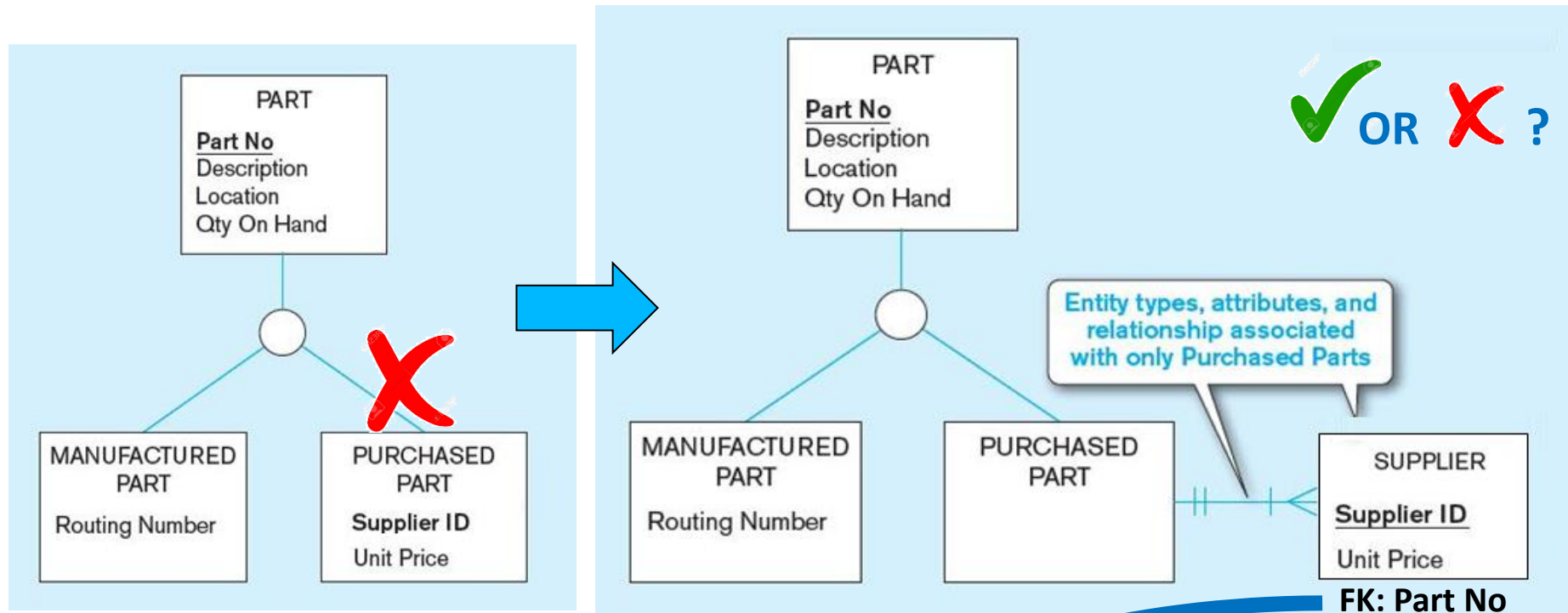
Part No	Supplier ID	Unit Price
12w	6695	80
12w	2095	50
..	...	...

X

Repeated PK
(that should
be the same as
supertype PK)

This still has a problem ...

Note: based on the “BR: Each part can be supplied by many suppliers” there are **multivalued composite attributes** in this ERD ...



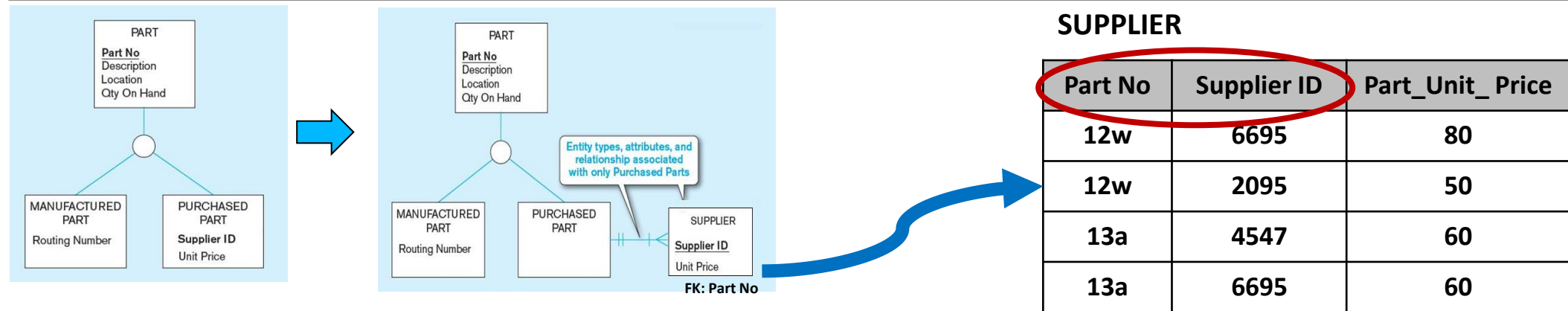
SUPPLIER

Part No	Supplier ID	Unit Price
12w	6695	80
12w	2095	50
13a	4547	60
13a	6695	60

Now there is no multivalued attribute or repeated PKs, but what if we had to store the **other information about the suppliers** like Supplier Name, Address, etc.?

In addition to the aforementioned issues related to **multivalued** attributes

The designed ERD will have some issues with storing **other information about the suppliers** like **Supplier Name, Address, etc.?**



Now there is no multivalued attribute or repeated PKs, but what if we had to store the **other information about the suppliers** like **Supplier Name, Address, etc.?**

Part No	Supplier ID	Sup_Name	Sup_Phone_No	Sup_Address	Part_Unit_Price
12w	6695	Fantastic Furniture	023445523	8/55 ... street	80
12w	2095	Brown Brothers	082374376	9/44 ... street ...	50
13a	4547	Max Quality	093761735	6/33 ... street ...	60
13a	6695	Fantastic Furniture	023445523	8/55 ..street	60



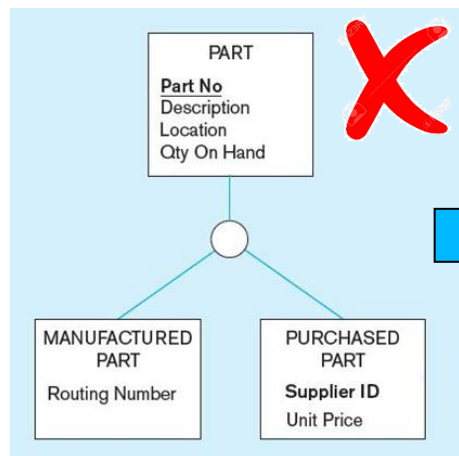
Now we have problem with **duplicate** data ...



In addition to the aforementioned issues related to **multivalued** attributes ...

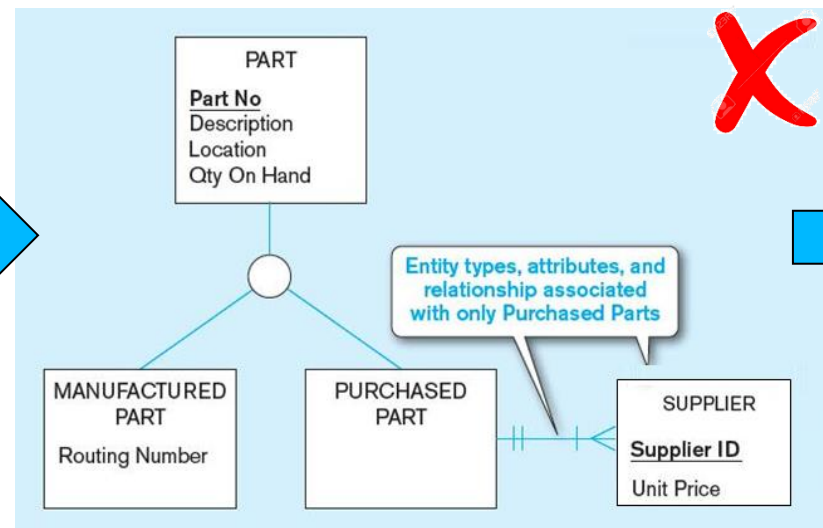
We had problem with **duplicate** data ...

The best solution is to have an **associative** entity between PURCHASED PART and SUPPLIER



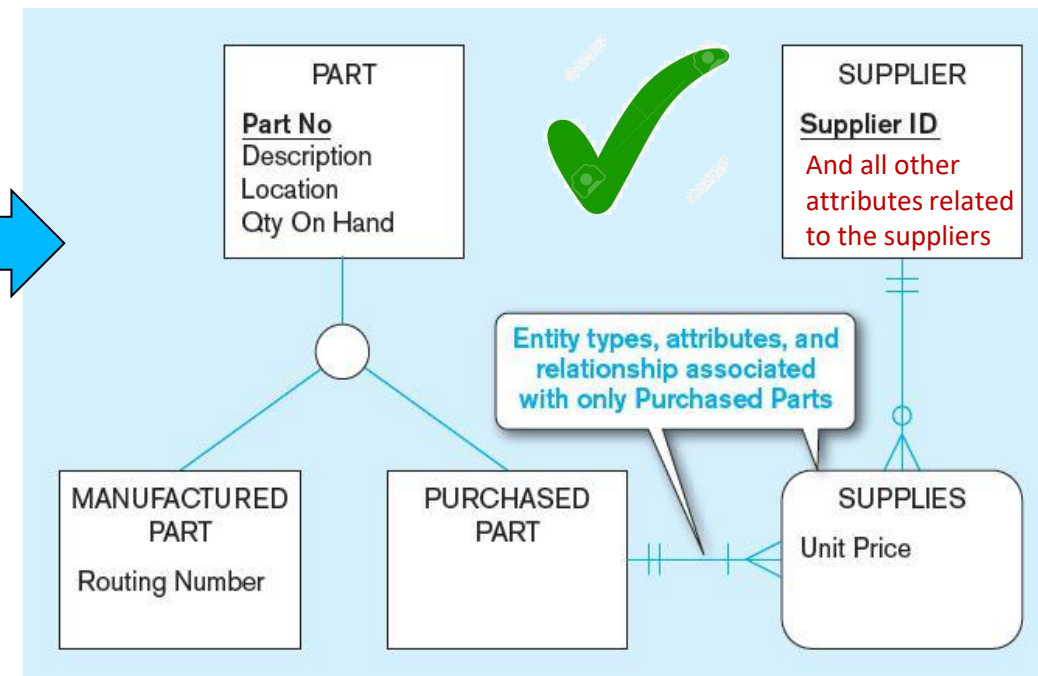
PURCHASED PART		
Part No	Supplier ID	Unit Price
12w	6695, 2095	80, 50
13a	4547, 6695	60, 60

Problem with **multivalued** data



SUPPLIER					
Part No	Supplier ID	SuName	SuPhoneNo	SuAddress	Unit Price
12w	6695	Fantastic Furniture	023445523	8/55 ... street	80
12w	2095	Brown Brothers	082374376	9/44 ... street ...	50
13a	4547	Max Quality	093761735	6/33 ... street ...	60
13a	6695	Fantastic Furniture	023445523	8/55 ..street	60

Now we have problem with **duplicate** data ...



Problems resolved

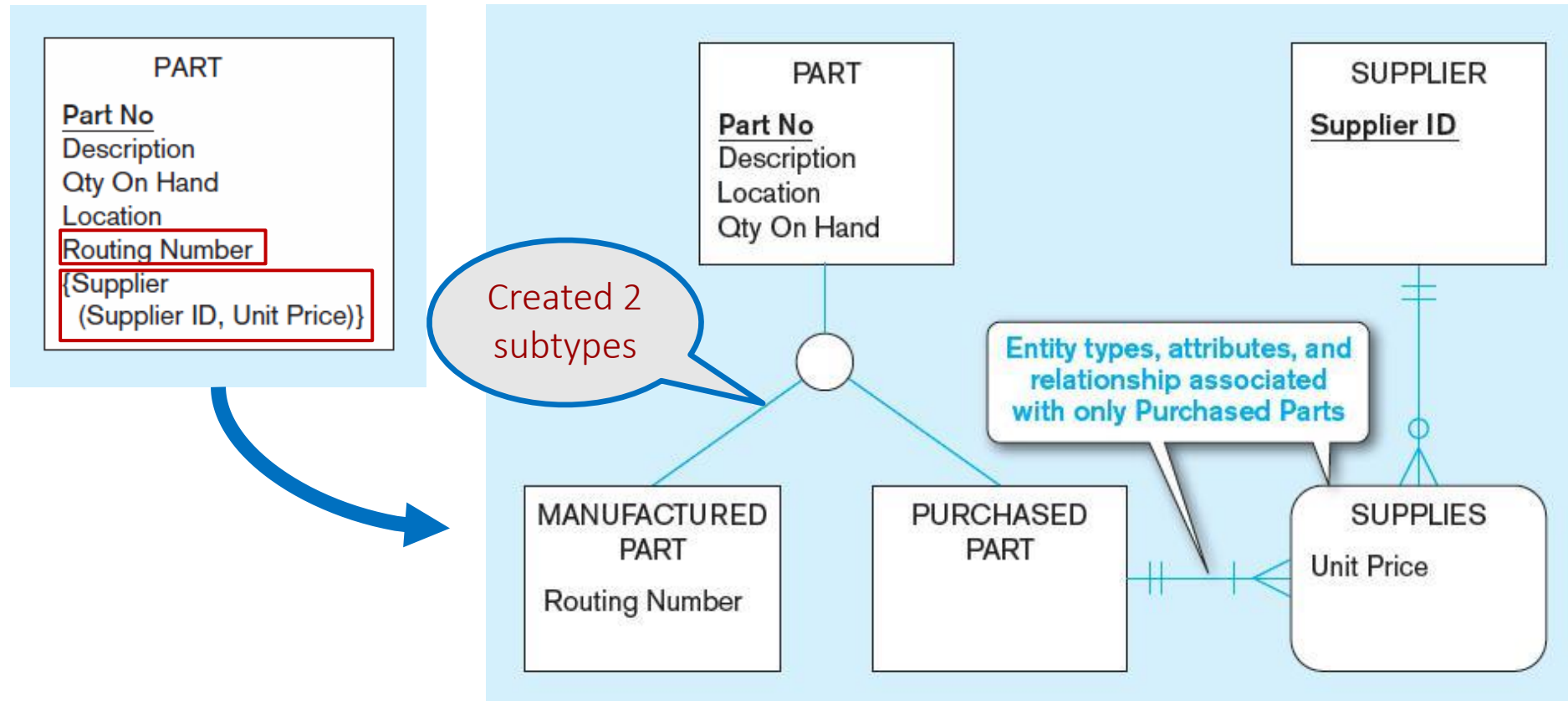


What are the PK and FKs in SUPPLIES?



Example of specialization (Figure 3-5) (cont.)

b) Specialization to **MANUFACTURED PART** and **PURCHASED PART**

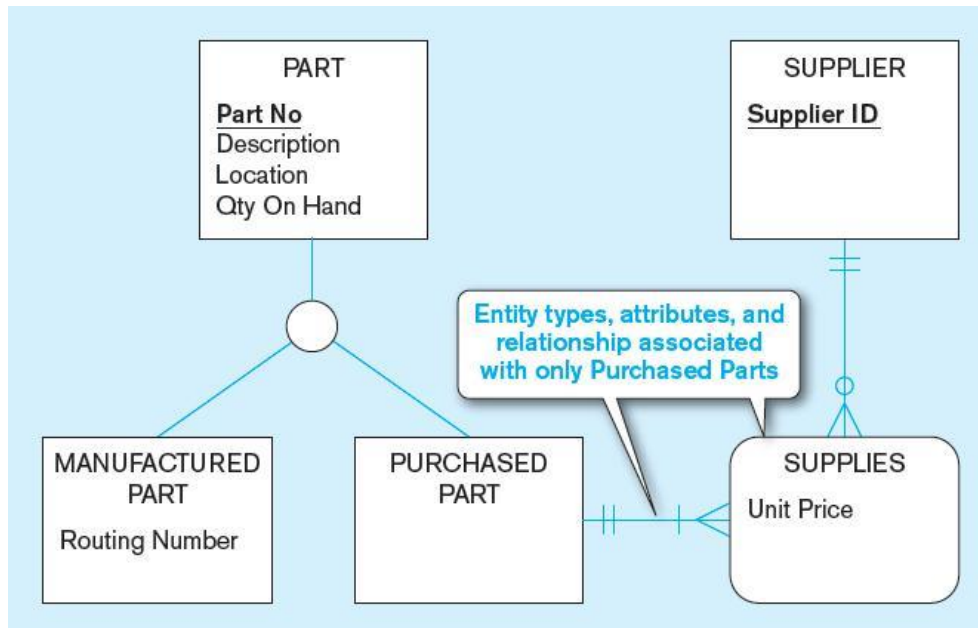


Note: multivalued composite attribute is replaced by an associative entity, a new entity, and two 1:M relationships.



Class Activity 4.5 (6 Minutes) → in the live lecture

Create the SUPPLIES table and determine its FKs and PK.

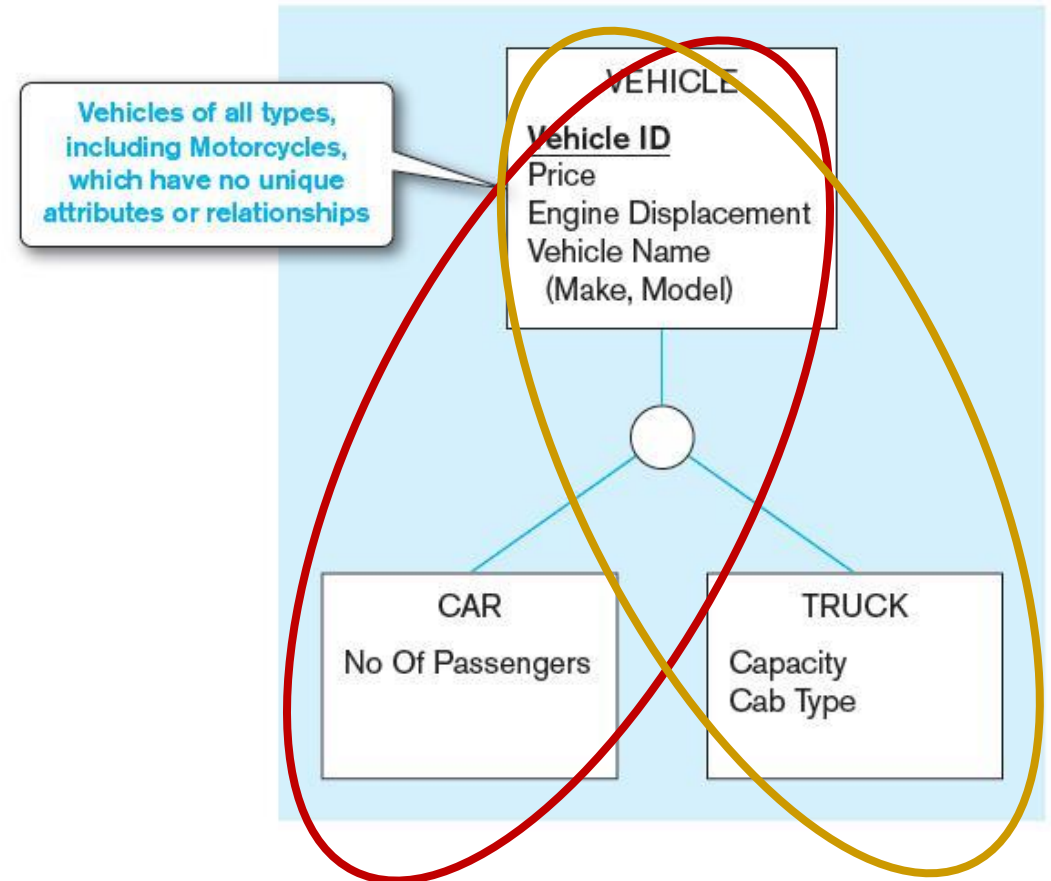




Class Activity 4.6(2 Minutes)

The property by which subtype entities possess the values of all attributes of a supertype is called

- A. hierarchy reception
- B. class management
- C. attribute inheritance
- D. generalization





Video 3.5: Constraints in Supertype/Subtype Relationships



4. Constraints in Supertype/Subtype Relationships

Constraints in Supertype/Subtype Relationships including:

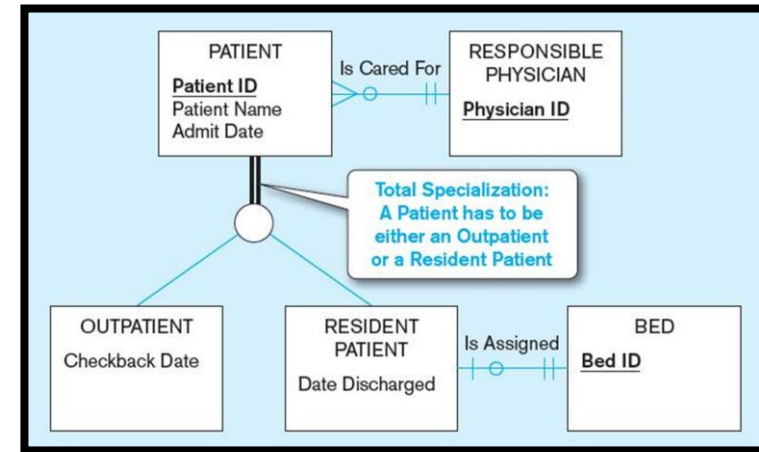
- 4.1. Completeness Constraints (Total or Partial Specialization)
- 4.2. Disjointness Constraints (Disjoint or Overlapping sub-types)
- 4.3. Subtype Discriminator

4.1. Constraints in Supertype: Completeness (Figure 3-6)

➤ **Completeness Constraints:** Whether an instance of a supertype *must* also be a member of at least one subtype

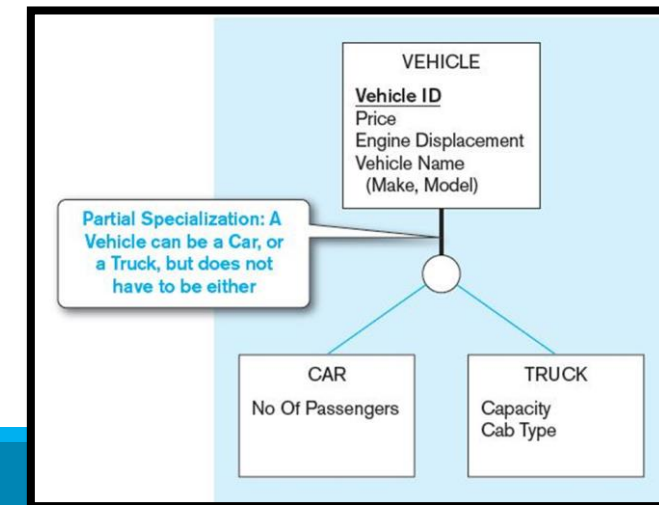
- **Total Specialization Rule:** Yes (double line)

- ✓ All possible subtypes are included



- **Partial Specialization Rule:** No (single line)

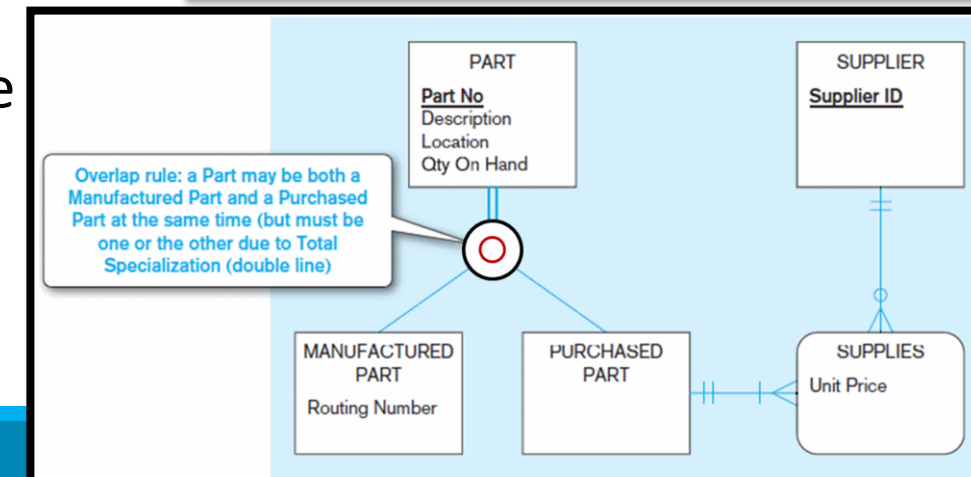
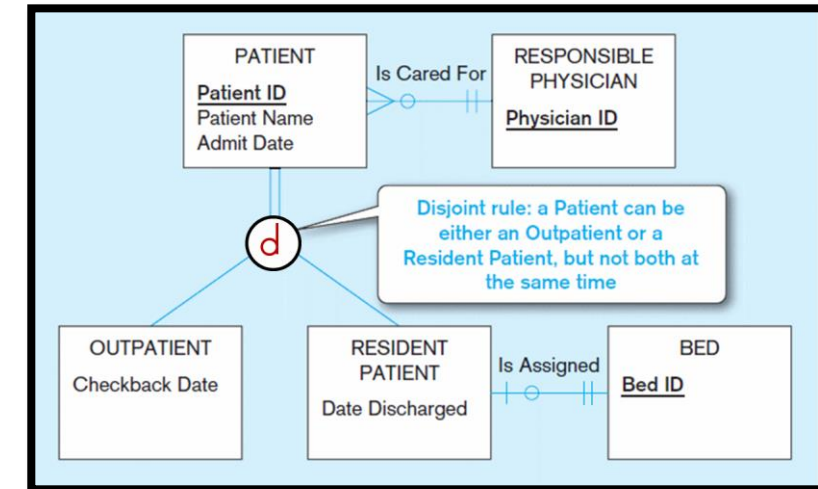
- ✓ There are more subtypes that have not been included yet.



4.2. Constraints in Supertype: Disjointness (Figure 3-7)

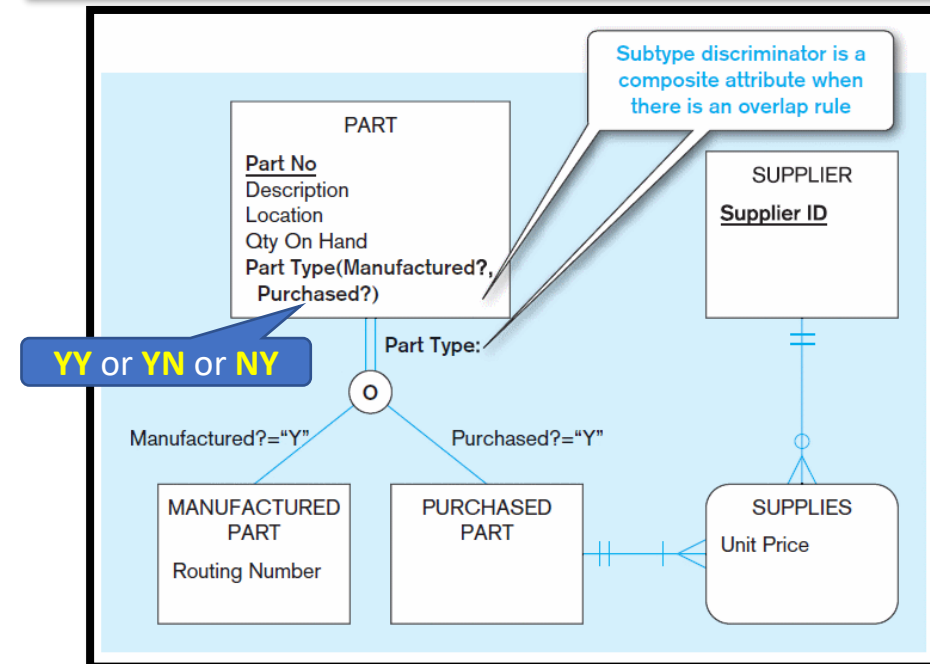
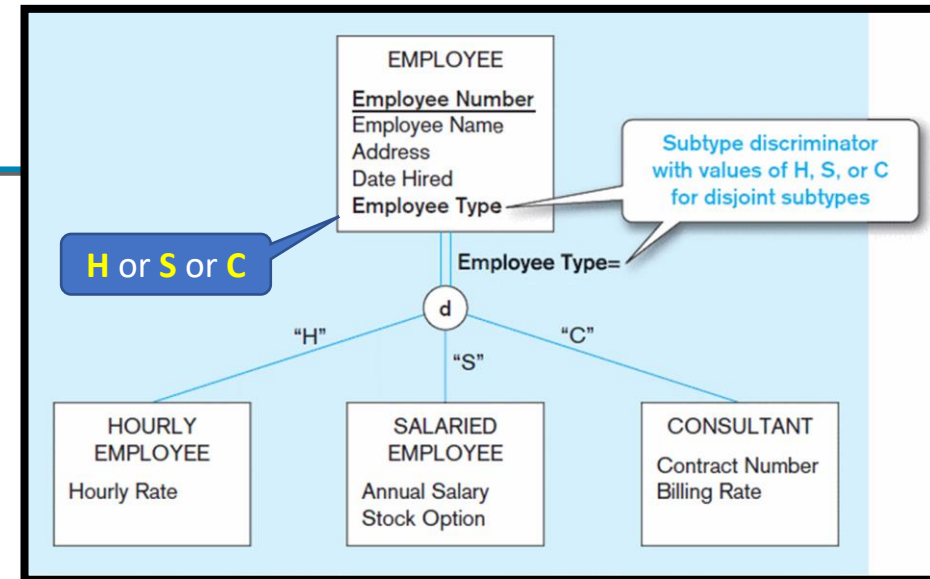
➤ **Disjointness Constraints:** Whether an instance of a supertype may *simultaneously* be a member of two (or more) subtypes

- **Disjoint Rule:** An instance of the supertype can be a member of **only ONE** of the subtypes.
- **Overlap Rule:** An instance of the supertype could be a member of **more than one** of the subtypes.



4.3. Constraints in Supertype: Subtype Discriminator

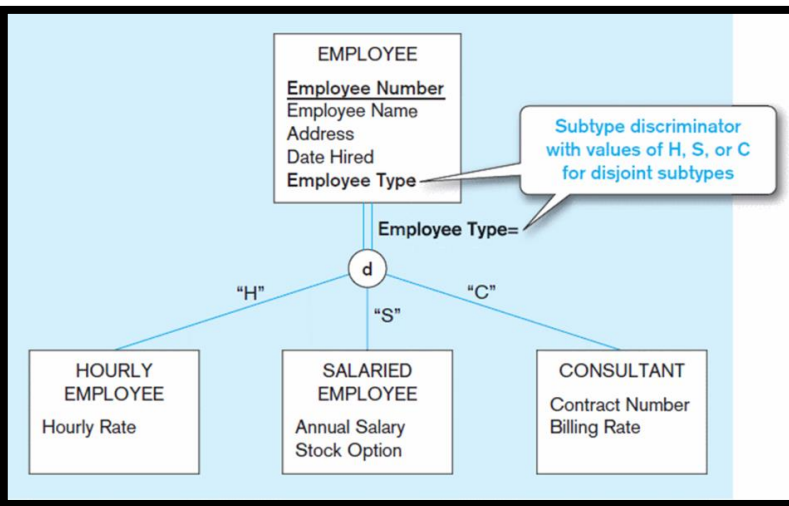
- **Subtype Discriminator:** An attribute of the supertype whose values determine the target subtype(s)
 - **Disjoint:** a **simple discriminator attribute** with alternative values to indicate the possible subtypes.
 - **Overlapping:** a **composite discriminator attribute** whose subparts pertain to different subtypes. **Each subpart** contains a **Boolean** value to indicate whether or not the instance belongs to the associated subtype.



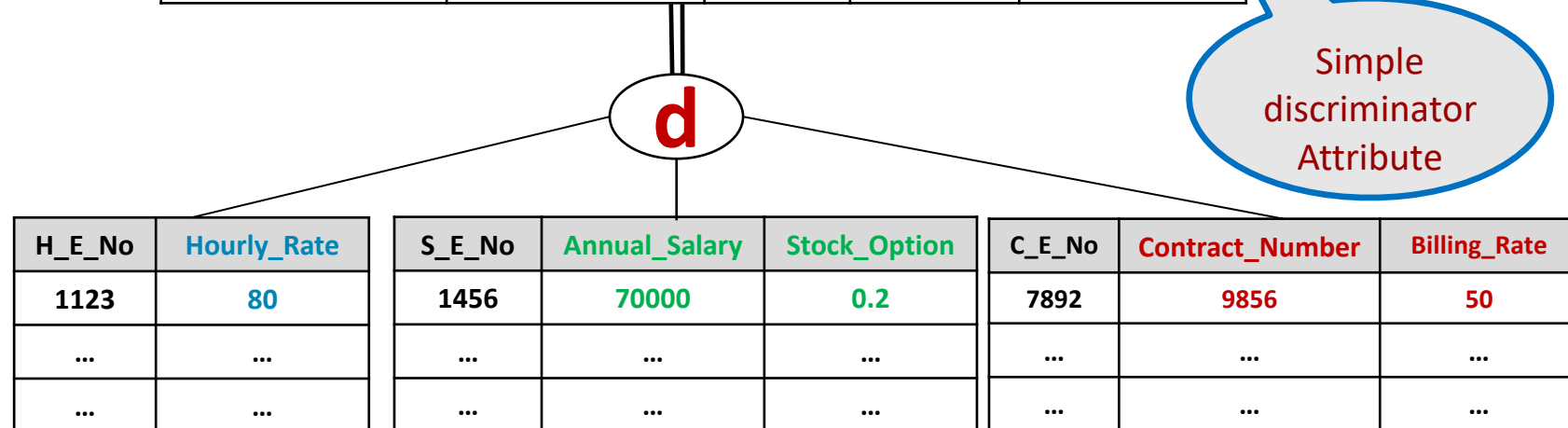


Introducing a subtype discriminator (*disjoint* rule)

- **Subtype Discriminator - Disjoint:** a **simple discriminator attribute** with alternative values to indicate the possible subtypes.



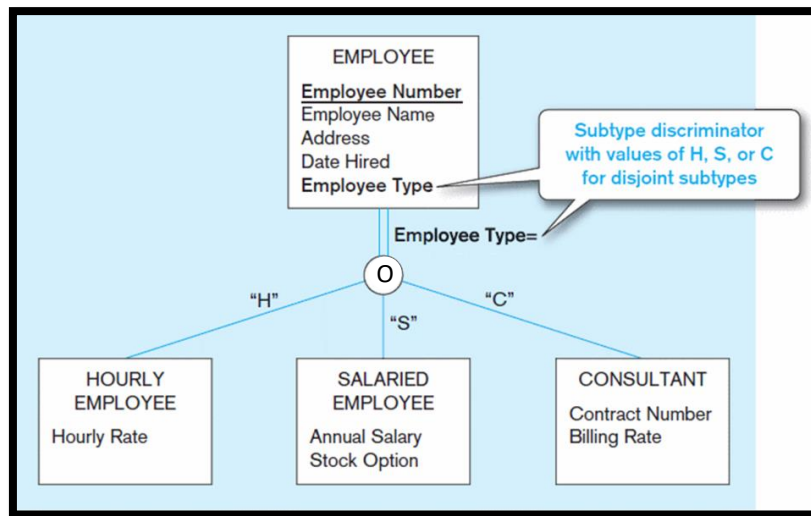
Employee_Number	Employee_Name	Address	Date_Hire	Employee_type
1123	Sara	UTS	1/1/2014	H
1456	Jake	32/50 ...	5/8/2013	S
7892	Fahimeh	12/97 ...	2/3/2013	C
...	...	...	...	...
...	...	...	...	...





Introducing a subtype discriminator (overlap rule)

- **Subtype Discriminator - Overlapping:** a **composite discriminator attribute** whose subparts pertain to different subtypes. Each **subpart** contains a Boolean value to indicate whether or not the instance belongs to the associated subtype.



Imagine Sara is a Casual **Consultant** with **hourly rate** payment ...

Employee_Number	Employee_Name	Address	Date_Hire	Employee_type (H? S? C?)
1123	Sara	UTS	1/1/2014	YNY
1456	Jake	32/50 ...	5/8/2013	NYN
7892	Danna	12/97 ...	2/3/2013	NNY
...	...	...	...	...
...	...	...	...	...

S_E_No	Hourly_Rate
1123	80
...	...
...	...

S_E_No	Annual_Salary	Stock_Option
1456	70000	0.2
...	...	...
...	...	...

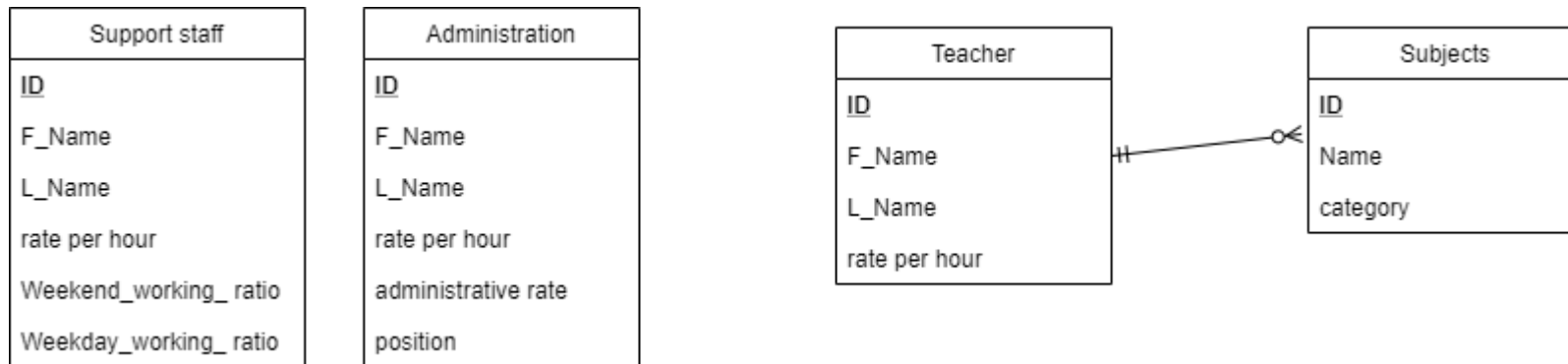
C_E_No	Contract_Number	Billing_Rate
7892	9856	50
1123	9812	30
...	...	...

Composite discriminator attribute



Class Activity 4.7 (6 Minutes) → in the live lecture

The database designer of a company have provided the following entities:



Your boss asked you to modify this design as the senior database designer of the company.



Solution to Class Activity 3.7



Class Activity 4.8

What is the name of the process you are taking to modify this design?

Support staff
<u>ID</u>
F_Name
L_Name
rate per hour
Weekend_working_ratio
Weekday_working_ratio

Administration
<u>ID</u>
F_Name
L_Name
rate per hour
administrative rate
position

Teacher
<u>ID</u>
F_Name
L_Name
rate per hour

Subjects
<u>ID</u>
Name
category

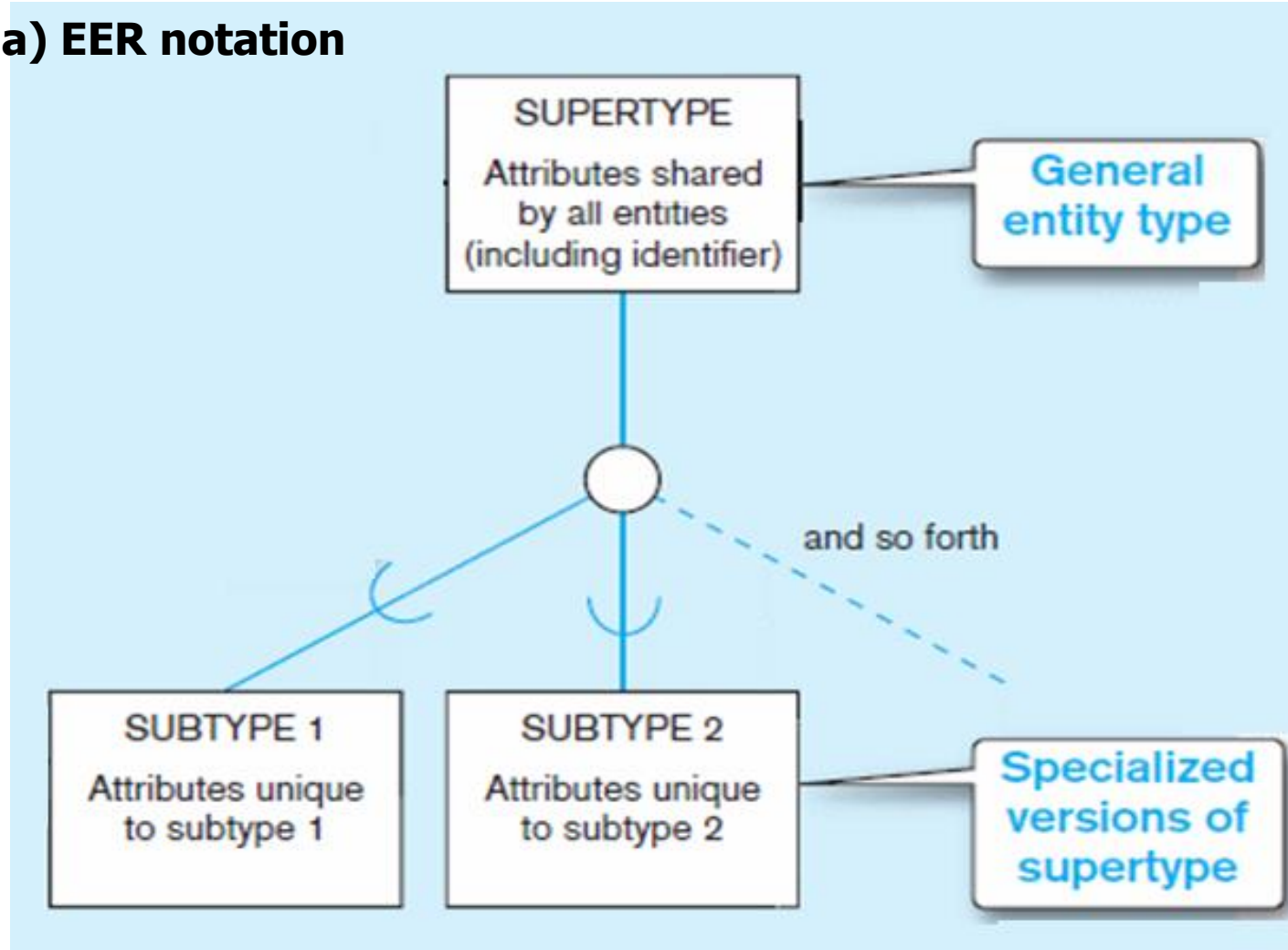




Notations

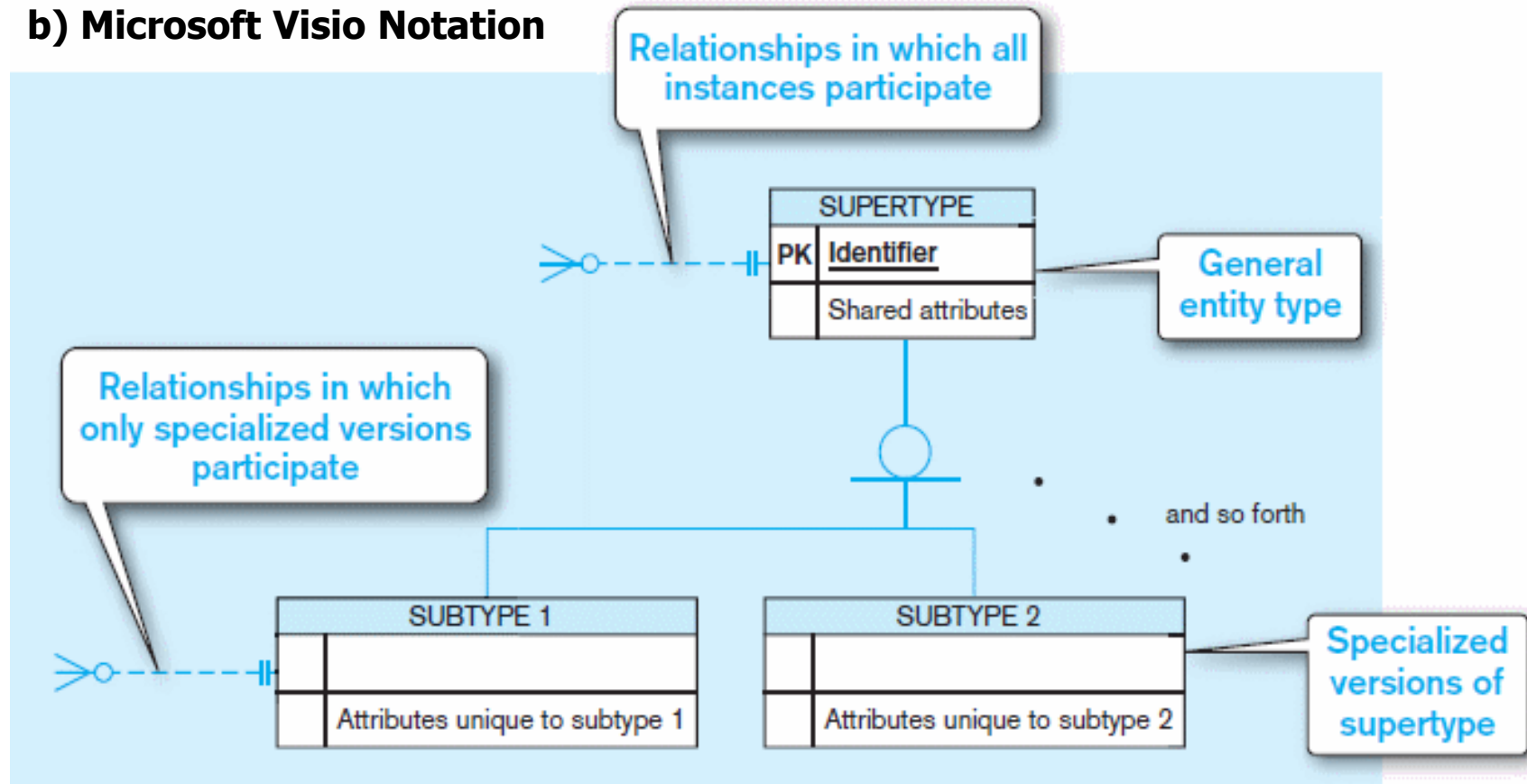
Basic notation for supertype/subtype notation (Figure 3-1: EER notation)

a) EER notation



Supertype/subtype relationships in a hospital (Figure 3-1: Microsoft Visio Notation)

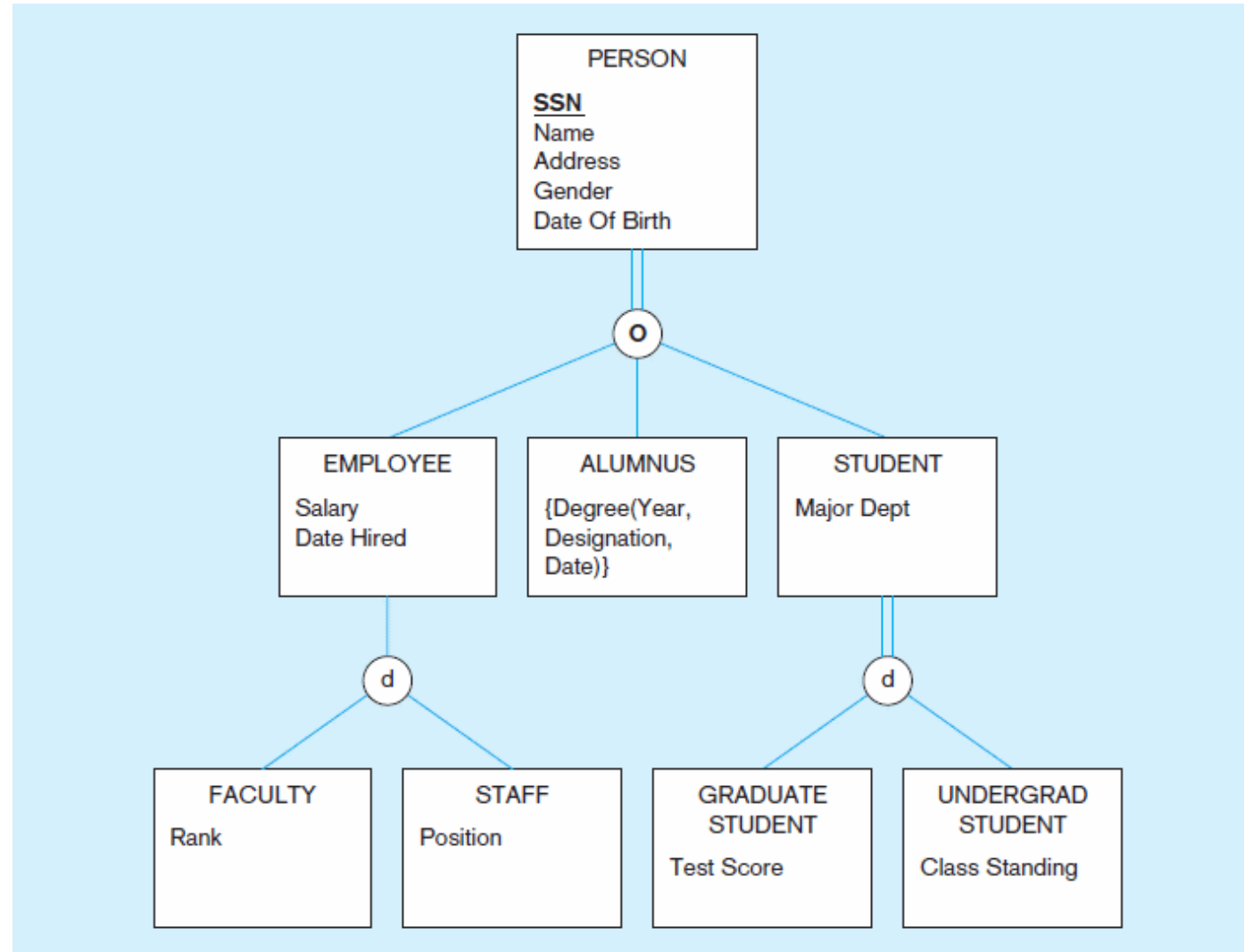
b) Microsoft Visio Notation



Different modeling tools may have different notation for the same modeling constructs.

Note: Do not use the Visio notation in your assignments.

Example of supertype/subtype hierarchy (Figure 3-1)



Summary

- ✓ Understand use of supertype/subtype relationships
- ✓ Understand use of specialization and generalization techniques
- ✓ Specify completeness and disjointness constraints
- ✓ Develop supertype/subtype hierarchies for realistic business situations

Next Lecture...

1. Components of relational model

2. Relations

2.1. Correspondence with E-R Model

2.2. Key Fields

2.3. Constraints

2.3.1. Domain Constraints

2.3.2. Entity Integrity

2.3.3. Action Assertions (Chapter 5)

3. Transforming EER Diagrams into Relations

3.1. Mapping Regular Entities to Relations (with simple, composite, and multivalued attributes)

3.2. Mapping Weak Entities

3.3. Mapping Binary Relationships (1:M, M:N, 1:1)

3.4. Mapping Associative Entities

3.5. Mapping Unary Relationships

3.6. Mapping Ternary (and n-ary) Relationships

3.7. Mapping Supertype/Subtype Relationships

Email structure to the subject coordinator:

The subject coordinator is more than happy to answer the emails from students that have the following requirements:

- The email is related to a **personal** issue, OR
- The information is not provided in the **subject outline** or the **assignment specification**, or is not posted in the **announcements**, OR
- Is not related to the subject contents.

Your email needs to have the following information in its **title**:

- **Subject Number (31271)**
- **Subject of the email (e.g. Request for Extension)**
- **First Name & Last Name**
- **Student ID**
- **Your tutorial name (e.g. Tut1-05)**

Considering the number of students in this subject (300), I need to say that we may not be able to answer emails that do not meet these requirements.

The response to the emails that do not meet the aforementioned requirements will be “**see the email structure in Lecture 4**”.

Many thanks and kind regards,
Danna



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