Database Technologies

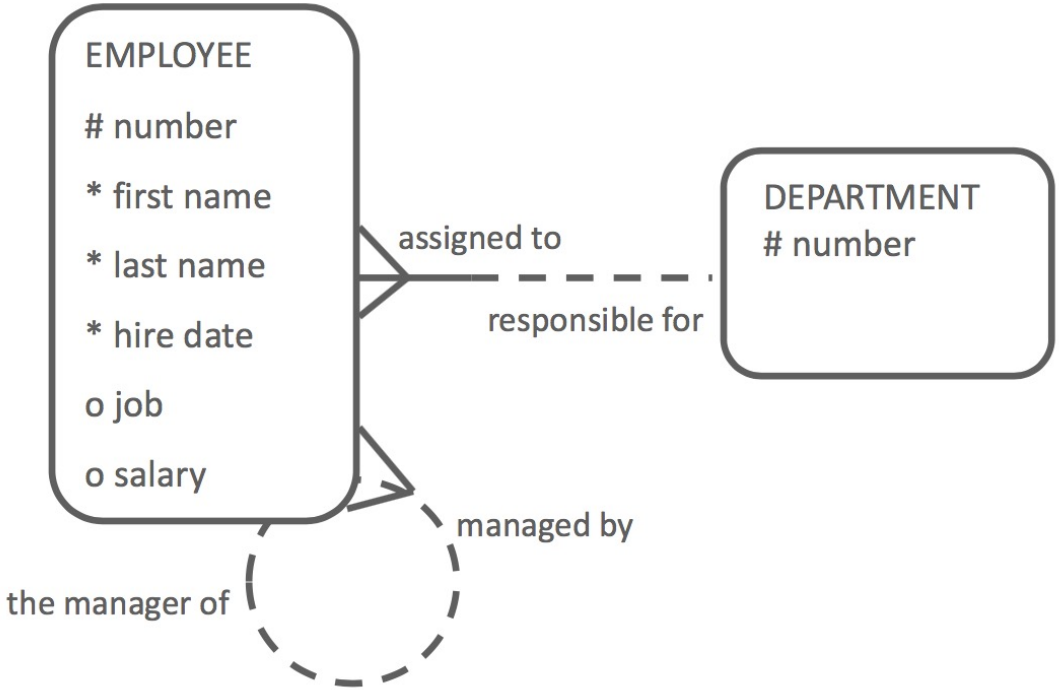
MS-218
Semester 1
Session 2021-22

Project Groups

- 3 students in each group
- Select a group leader
- Group leader will email me group info, like names and registration numbers of other students. Please keep other members in CC
- If you have any difficulty in finding group members, then please email me, jamal.nasir@nuigalway.ie

Step-1 Conceptual Data Modeling

- An entity relationship diagram (ERD) should completely capture and accurately model the organization's information needs and support the functions of the business.



What is Optionality in a Relationship?

- Relationships are either mandatory or optional.
- Consider the two entities EMPLOYEE and JOB.
- Based on what you know about instances of the entities, you can determine optionality by answering two questions:
- Must every employee have a job?
  – In other words, is this a mandatory or optional relationship for an employee?
- Must every job be assigned to an employee?
  – In other words, is this a mandatory or optional relationship for a job?

What is Cardinality in a Relationship?

- Cardinality measures the quantity of something.
- In a relationship, it determines the degree to which one entity is related to another by answering the question, “How many?”
- For example:
  – How many jobs can one employee hold? One job only? Or more than one job?
- – How many employees can hold one specific job? One employee only? Or more than one employee?
- • Note: The cardinality of a relationship only answers whether the number is singular or plural; it does not answer with a specific plural number.

Optionality and Cardinality

Examples:

- Each EMPLOYEE must hold one and only one JOB
- Each JOB may be held by one or more EMPLOYEEs
- Each PRODUCT must be classified by one and only one PRODUCT TYPE
- Each PRODUCT TYPE may classify one or more PRODUCTs

Business Scenario

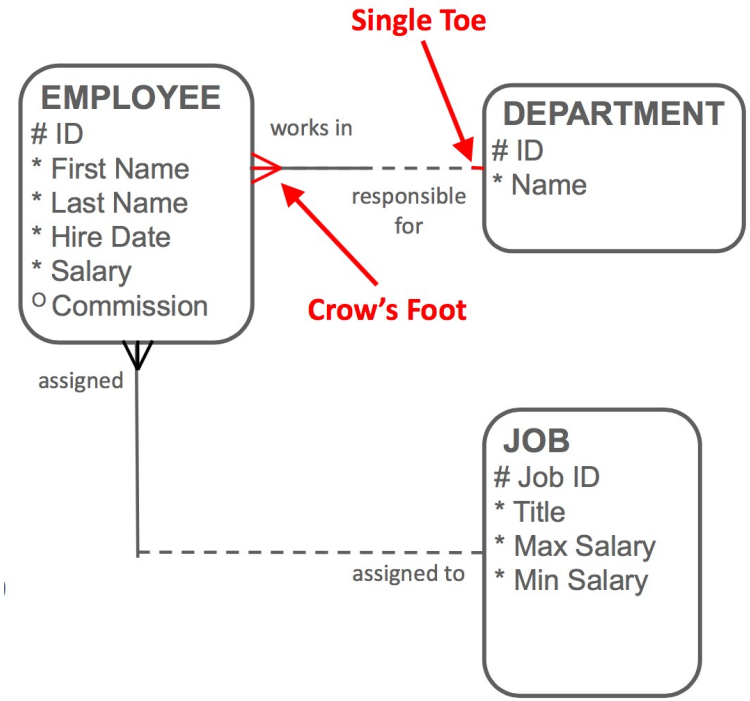
- A relationship can join one entity to itself.
- Examine the following scenario:
- “We need to keep track of our employees and their managers. Every employee has one manager, including the managing director who manages him/herself. Each manager can manage several employees.”

Business Scenario

- Since managers are also employees, both are listed in the same entity: EMPLOYEE.
- Relationships?
- Each **EMPLOYEE** may be managed by one and only one **EMPLOYEE**
- Each **EMPLOYEE** may manage one or more **EMPLOYEEs**

Drawing Conventions for Relationships

- Relationships are lines that connect entities.
- These lines are either solid or dashed.
- These lines terminate in either a “single toe” or a “crow’s foot” at the end of each entity.



Relationships in ERD

- Since each relationship has two sides, we read the first relationship from left to right (or top to bottom, depending on the ERD layout).
- Formula (Business Rule → Relationship)

Business Rule
Each
EMPLOYEE
Must
Work in
One and Only One
DEPARTMENT

Business Rule
Each
Entity A
OPTIONALITY (must be/may be)
RELATIONSHIP NAME
CARDINALITY (one and only one/one or more)
Entity B

Relationships in ERD

- Each
- **EMPLOYEE** (entity A)
- MUST (optionality, solid line)
- **WORK IN** (relationship name)
- **ONE** (AND ONLY ONE) (cardinality, single toe)
- **DEPARTMENT** (entity B)

Relationships in ERD

- Now we read the relationship from right to left.

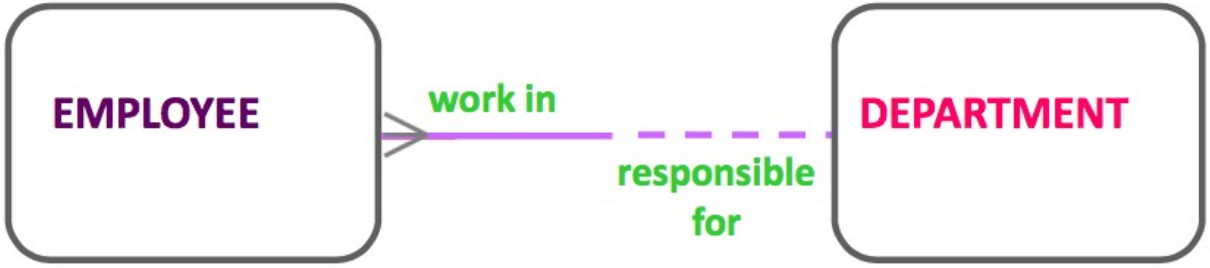
1. EACH
2. Entity B
3. OPTIONALITY (must be/may be)
4. RELATIONSHIP NAME
5. CARDINALITY (one and only one/one or more)
6. Entity A

Breaking Down ERDish

1. EACH
2. **DEPARTMENT** (entity B)
3. **MAY BE** (optionality, dotted line)
4. **RESPONSIBLE FOR** (relationship name)
5. **ONE OR MORE** (cardinality, crow's foot)
6. **EMPLOYEE** (entity A)

Relationships in ERD

- Now bring it all together.



1. EACH
2. **EMPLOYEE** (entity A)
3. **MUST** (optionality, solid line)
4. **WORK IN** (relationship name)
5. **ONE AND ONLY ONE** (cardinality, single toe)
6. **DEPARTMENT** (entity B)

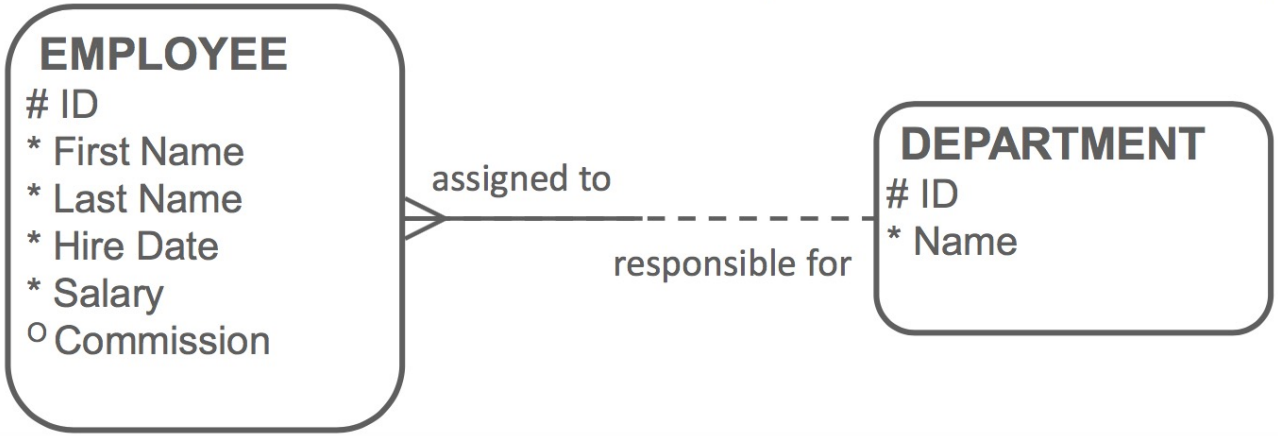
1. EACH
2. **DEPARTMENT** (entity B)
3. **MAY BE** (optionality, dotted line)
4. **RESPONSIBLE FOR** (relationship name)
5. **ONE OR MORE** (cardinality, crow's foot)
6. **EMPLOYEE** (entity B)

Relationship Transferability

- Once a class has been allocated to a teacher, can that class later be transferred to another teacher, possibly in mid- semester?
- Usually yes, because if not, what would we do if the original teacher becomes sick?
- Some health clubs allow memberships to be transferred from one person to another, but other health clubs don’t.
- This business rule is normally determined by what is most efficient and most profitable for the club.

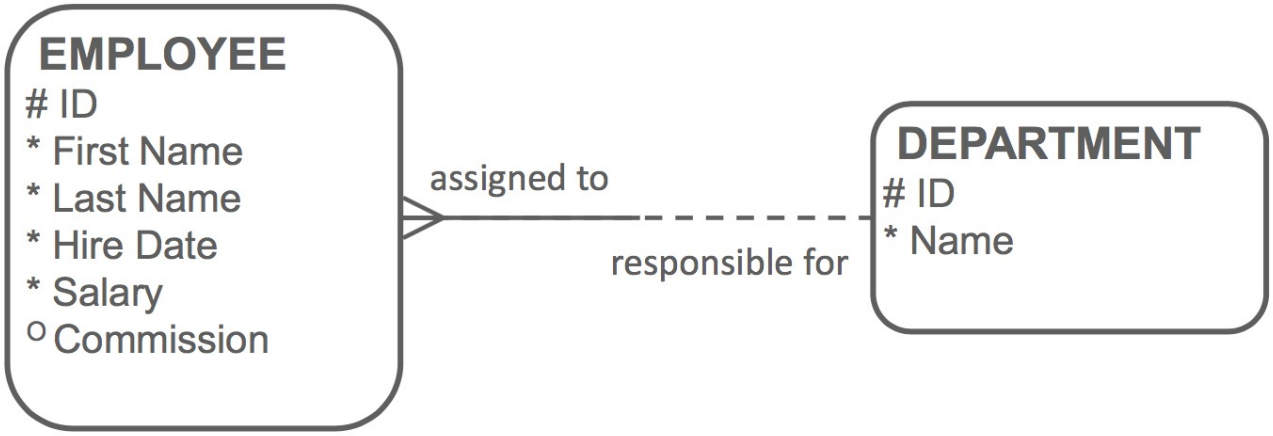
Relationship Review

- Let's review a simple relationship between EMPLOYEE and DEPARTMENT.
- Optionality:
  - Must every EMPLOYEE be assigned to a DEPARTMENT?
  - Must every DEPARTMENT be responsible for an employee?



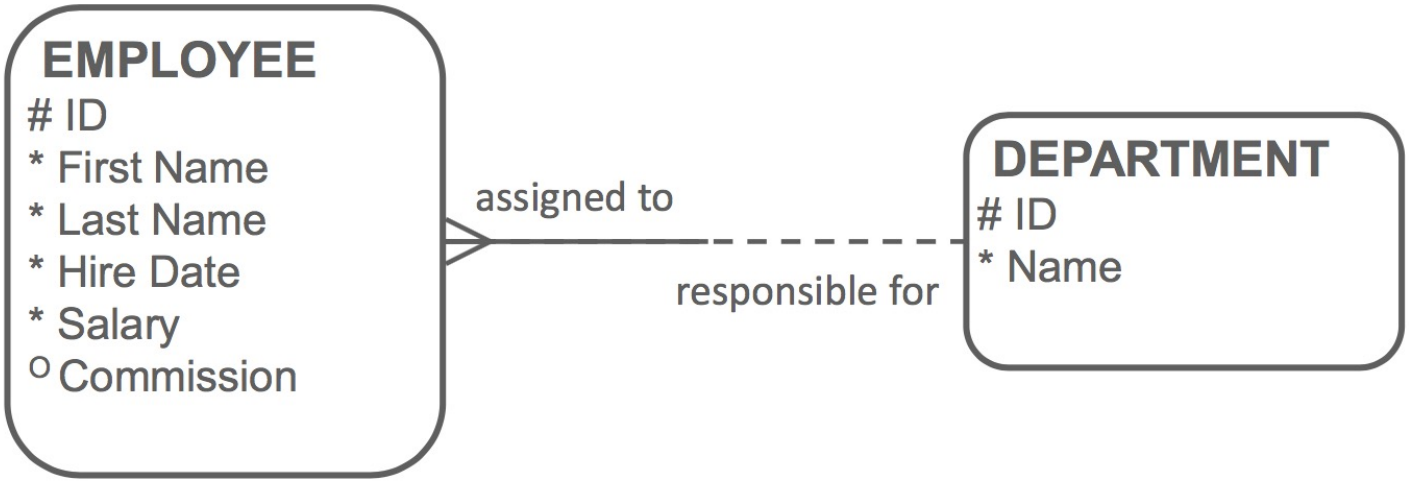
Relationship Review

- Cardinality:
  - How many EMPLOYEEs can a DEPARTMENT be responsible for?
  - How many DEPARTMENTs can an EMPLOYEE be assigned to?



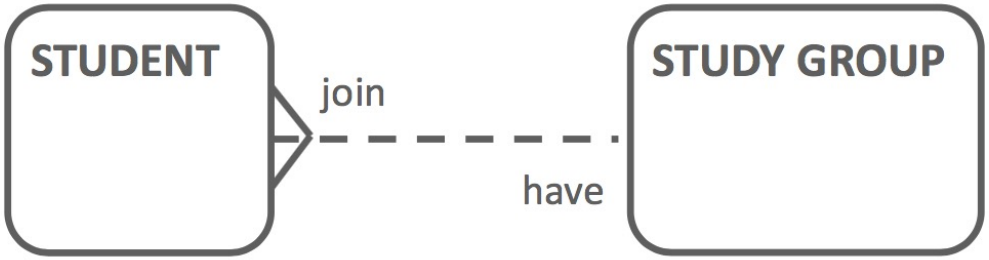
Relationship Review

- Transferability:
  - Can an EMPLOYEE be transferred from one DEPARTMENT to another DEPARTMENT?



Relationship Transferability

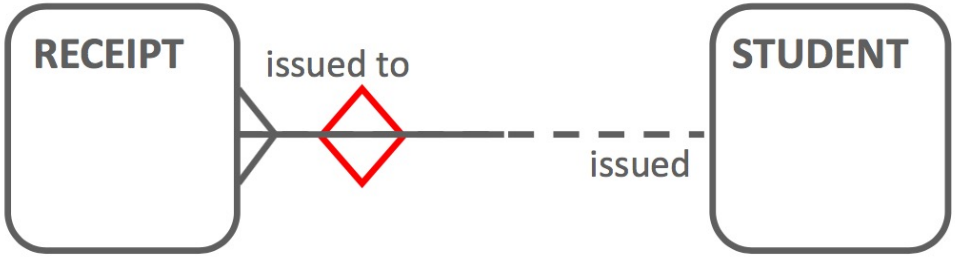
- Transferable: A STUDENT being allowed to move from one STUDY GROUP to another.
- There is a relationship between STUDENT and STUDY GROUP that is transferable.



Transferable Relationship

Relationship Transferability

- Nontransferable: A STUDENT can be issued a RECEIPT for paying tuition fees, taking a certification exam, or purchasing items at the bookstore.
- Once a RECEIPT has been issued, it cannot be transferred to another STUDENT.

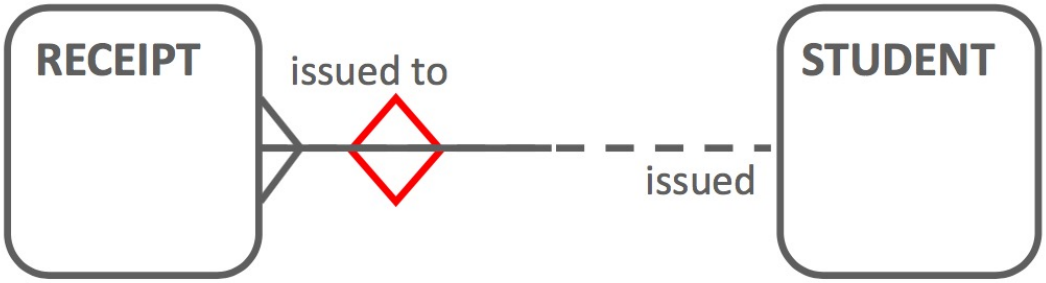


Nontransferable Relationship

A nontransferable relationship is represented with the diamond on the relationship

Relationship Transferability

- If it was issued in error, it would have to be cancelled, and another RECEIPT would have to be written up.
- The relationship between STUDENT and RECEIPT is nontransferable.

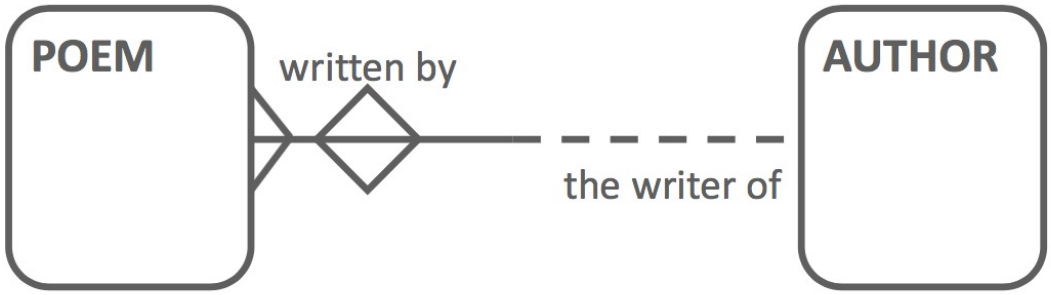


Nontransferable Relationship

A nontransferable relationship is represented with the diamond on the relationship.

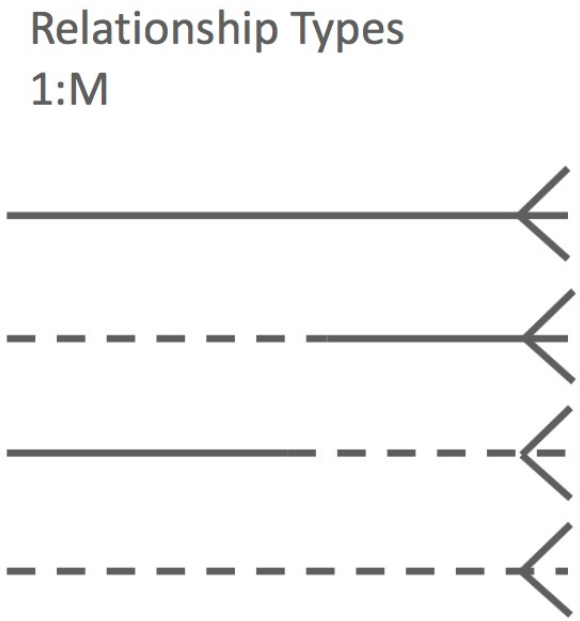
More Nontransferable Relationships

- Ownership of a POEM belongs with its AUTHOR.
- Authorship is a relationship that cannot be moved to another person.



One-to-Many (1:M) Relationships

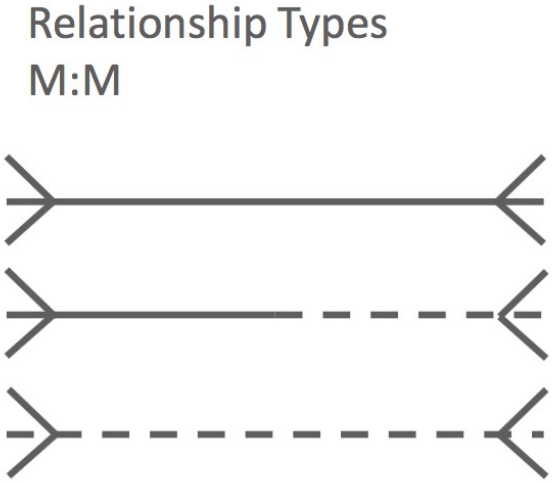
- The various types of 1:M relationships are most common in an ER Model.
- You have seen several examples already.

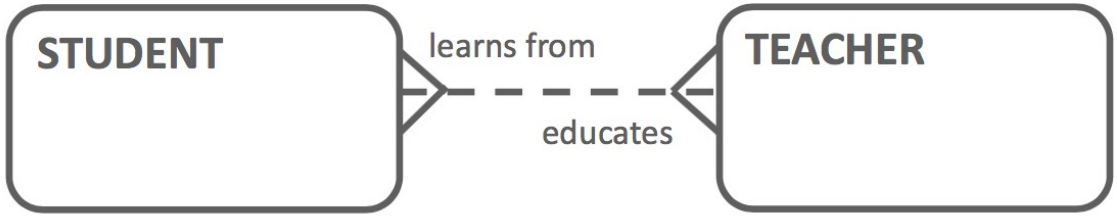


1:M Relationship

Many-to-Many (M:M) Relationships

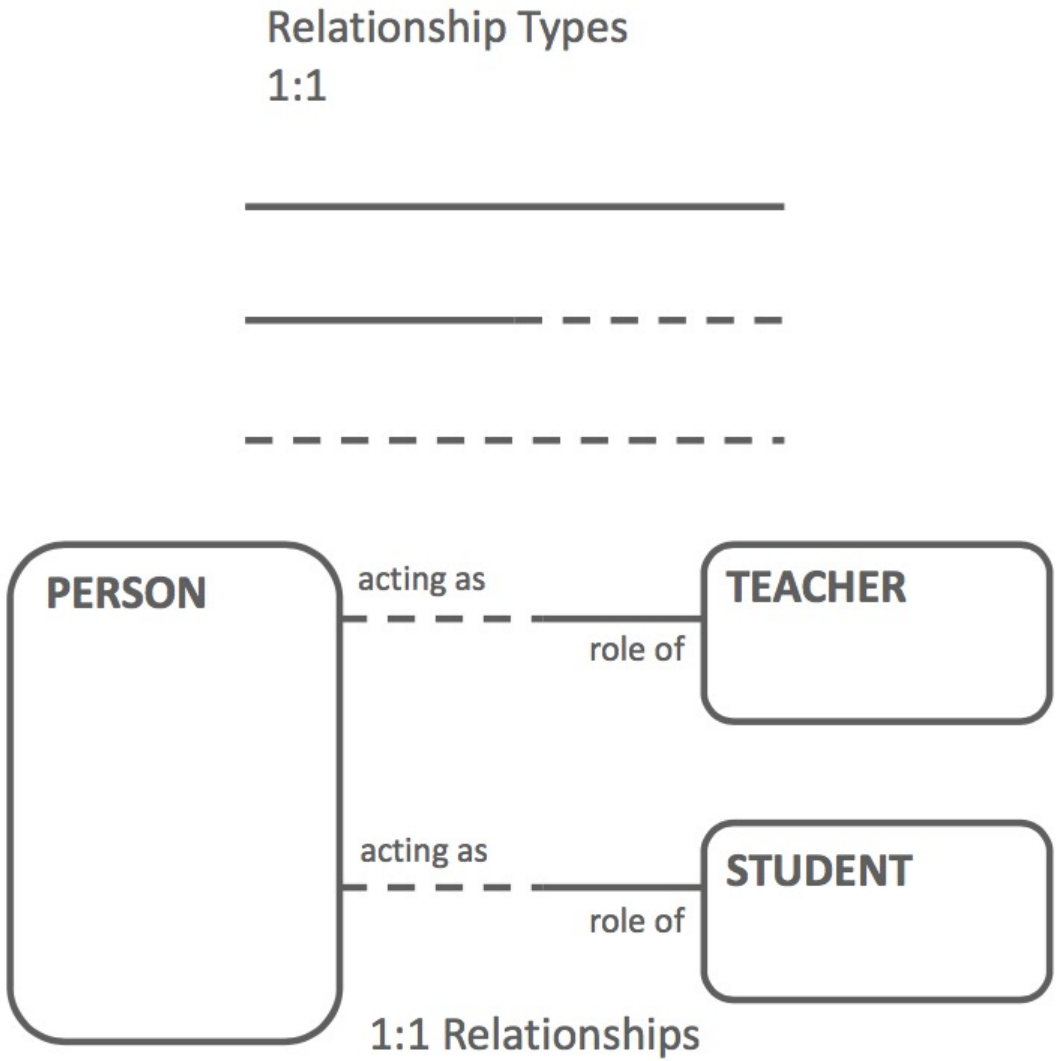
- The various types of M:M relationships are common, particularly in a first version of an ER model.
- In later stages of the modeling process, all M:M relationships will be resolved, and disappear.





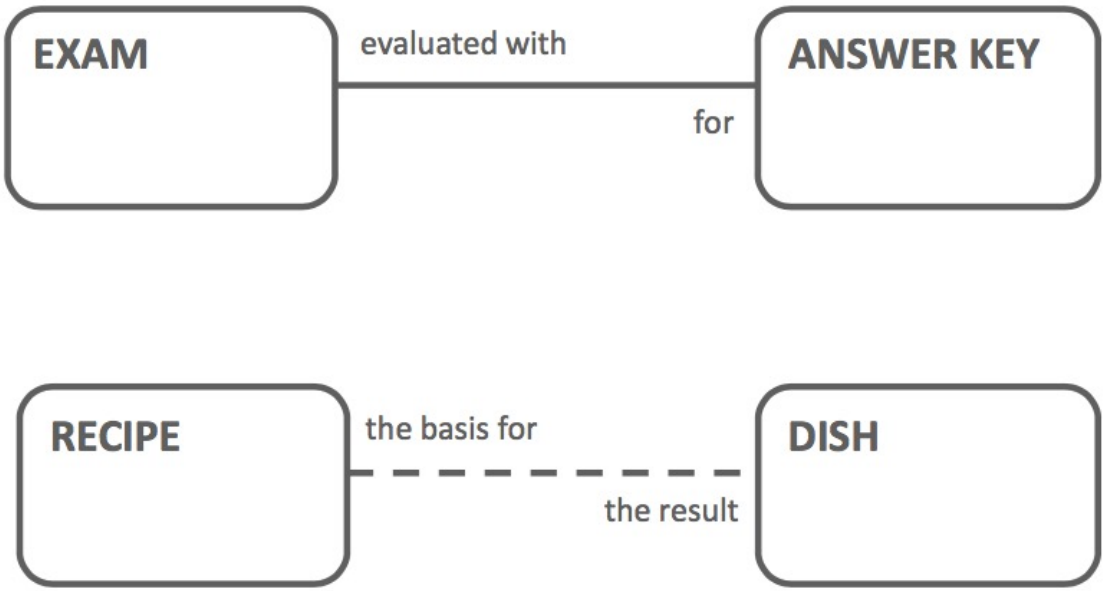
One-to-One Relationships For Roles

- Usually you will find just a few of the various types of 1:1 relationships in every ER model.
- Mandatory at one end of the 1:1 relationship commonly occurs when roles are modeled.



One-to-One Relationships For Processes

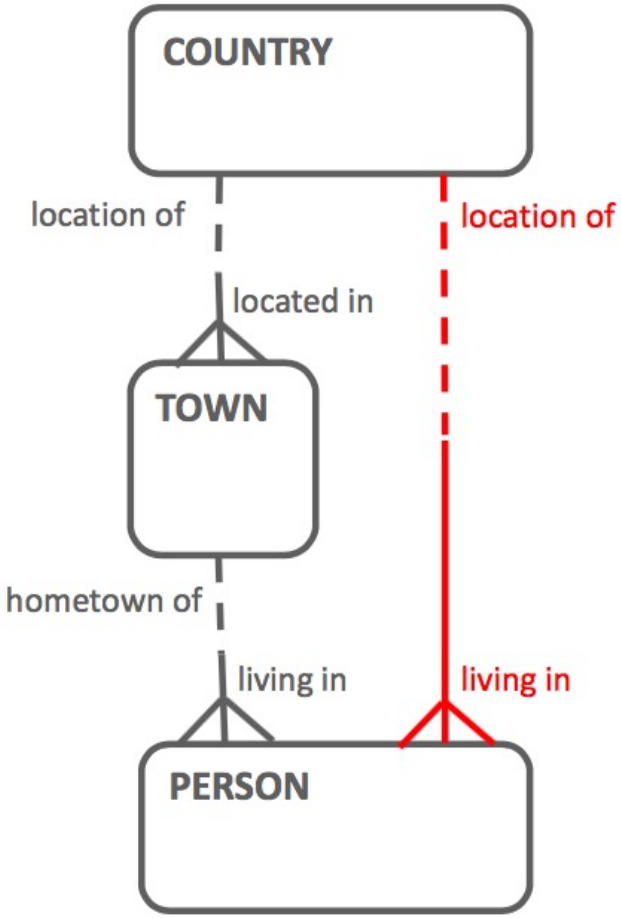
- 1:1 relationships (of all three variations) also occur when some of the entities represent various stages in a process.



1:1 Process Relationships

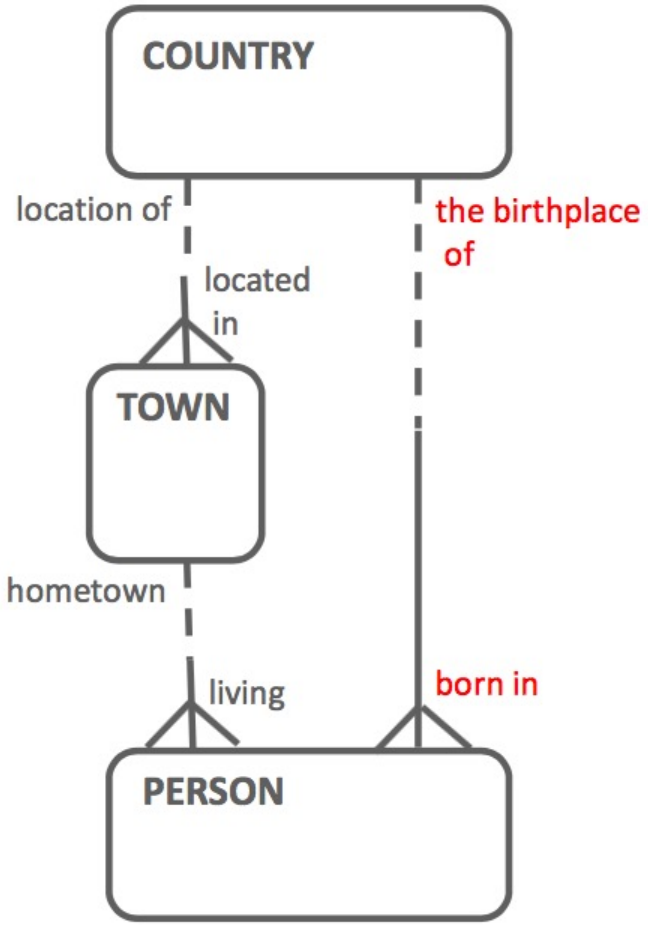
Redundant Relationships

- A redundant relationship can be derived from another relationship in the model.
- In this example, you can derive the relationship from PERSON to COUNTRY from the other two relationships (COUNTRY to TOWN, TOWN to PERSON), so you should remove the direct relationship from COUNTRY to PERSON .



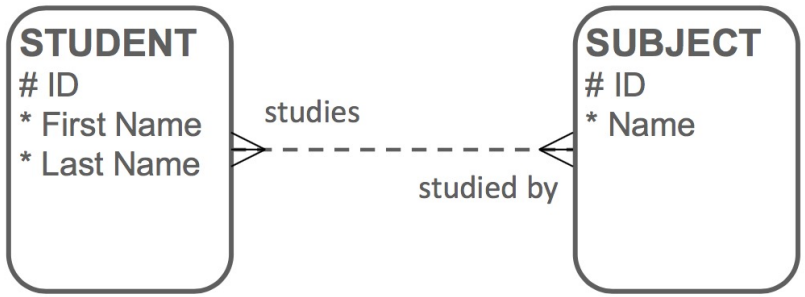
Redundant Relationships

- However, be careful of concluding that a relationship is redundant based on the structure alone.
- Read the relationships to check.
- The ERD shown here does not reflect a redundant relationship.



Resolving Many-to-Many Relationships

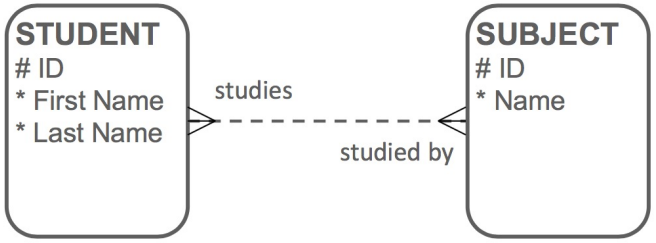
- Relationship Hiding an Attribute
- In a school, a STUDENT may study one or more SUBJECTs.
- Each SUBJECT may be studied by one or more STUDENTs



STUDENT and SUBJECT

Relationship Hiding an Attribute

- When a student enrolls for a subject, we want to be able to record the grade they attain for that subject.
- Which entity would the attribute “Grade” belong to?
- If we put “Grade” in the STUDENT entity, how would we know which SUBJECT it is for?
- If we put “Grade” in the SUBJECT entity, how would we know which STUDENT got that grade?



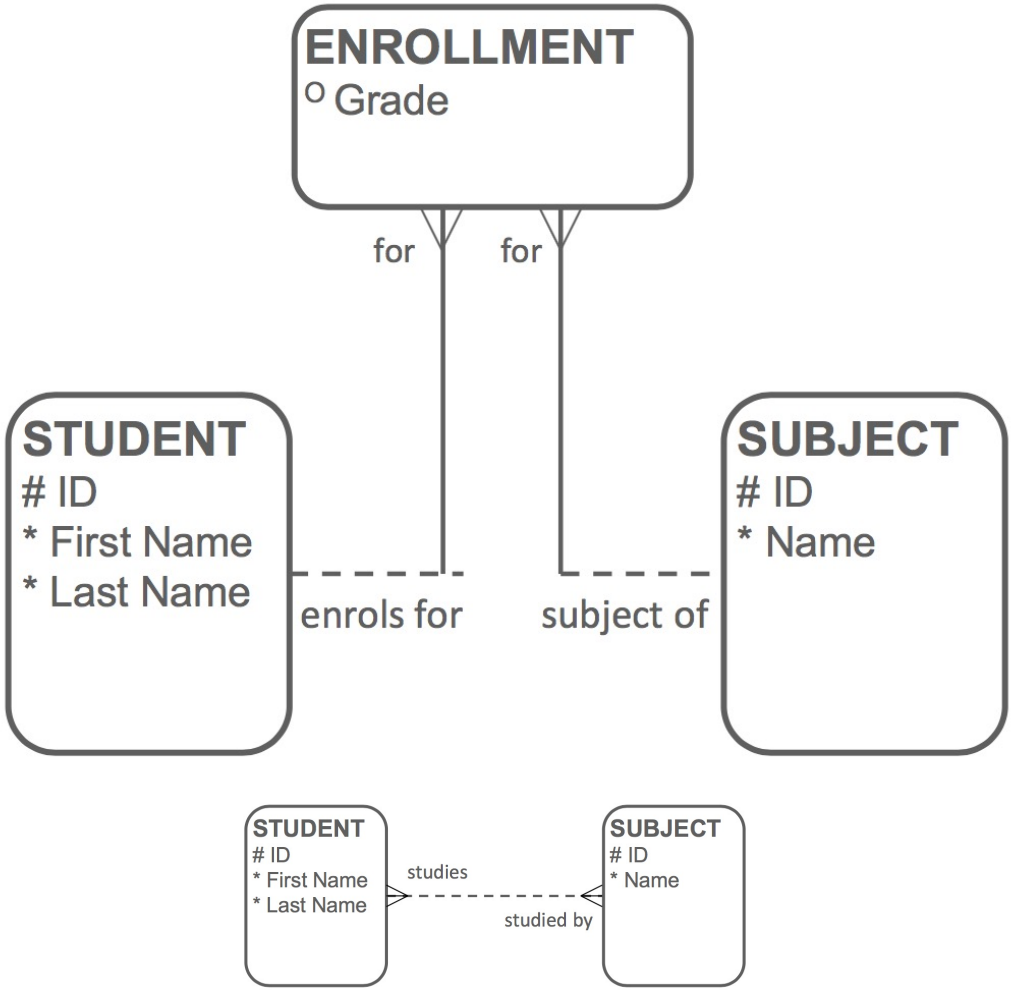
STUDENT and SUBJECT

Resolution of a M:M Relationship

- A third entity is needed to resolve the M:M relationship. This is called an "intersection" entity.

Intersection Entity

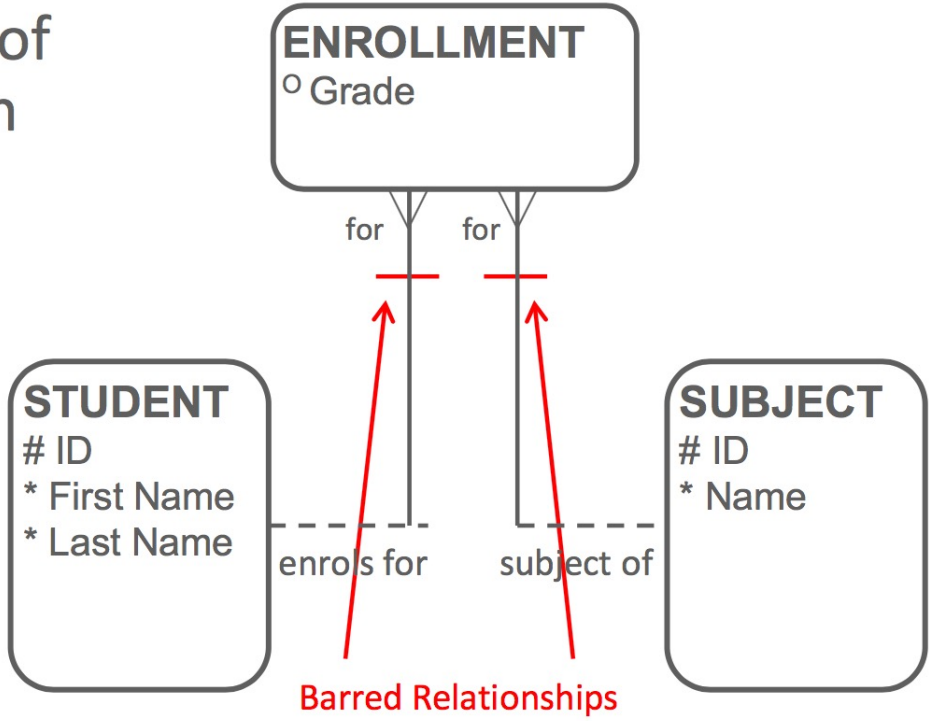
- An intersection entity – ENROLLMENT – has been added, including the "Grade" attribute.
- The original M:M relationship has become two 1:M relationships.
- What would be the UID of the intersection entity?



STUDENT and SUBJECT

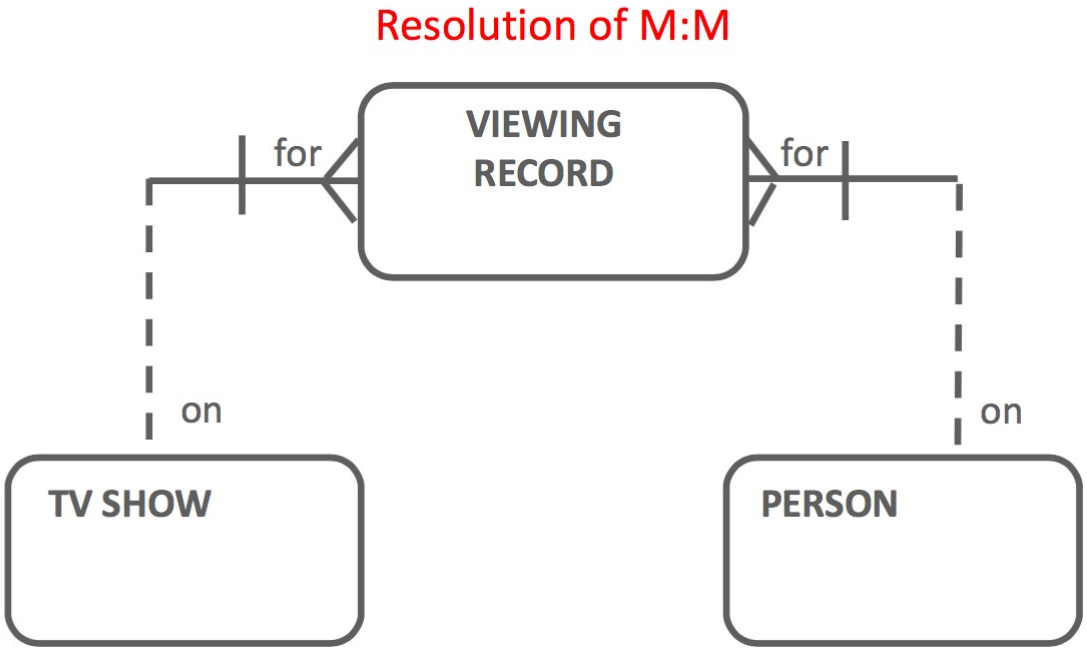
Barred Relationships

- The unique identifier (UID) of the intersection entity often comes from the originating relationships and is represented by the bars.
- In this case, the relationships from the originating entities to the intersection entity are called "barred" relationships.



M:M Resolution Example TV Shows

- Each TV show may be watched by one or more persons.
- Each person may watch one or more TV shows.

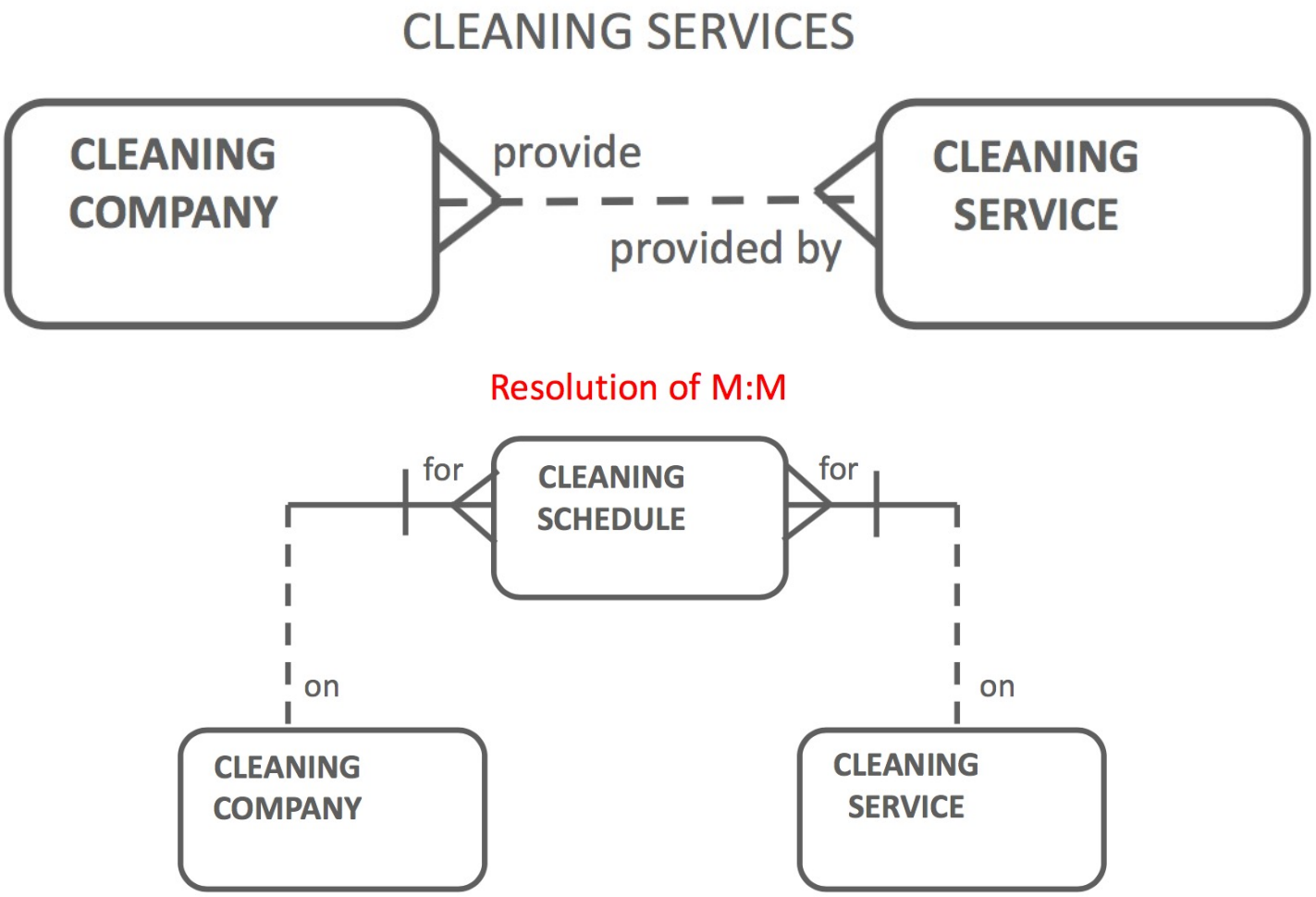


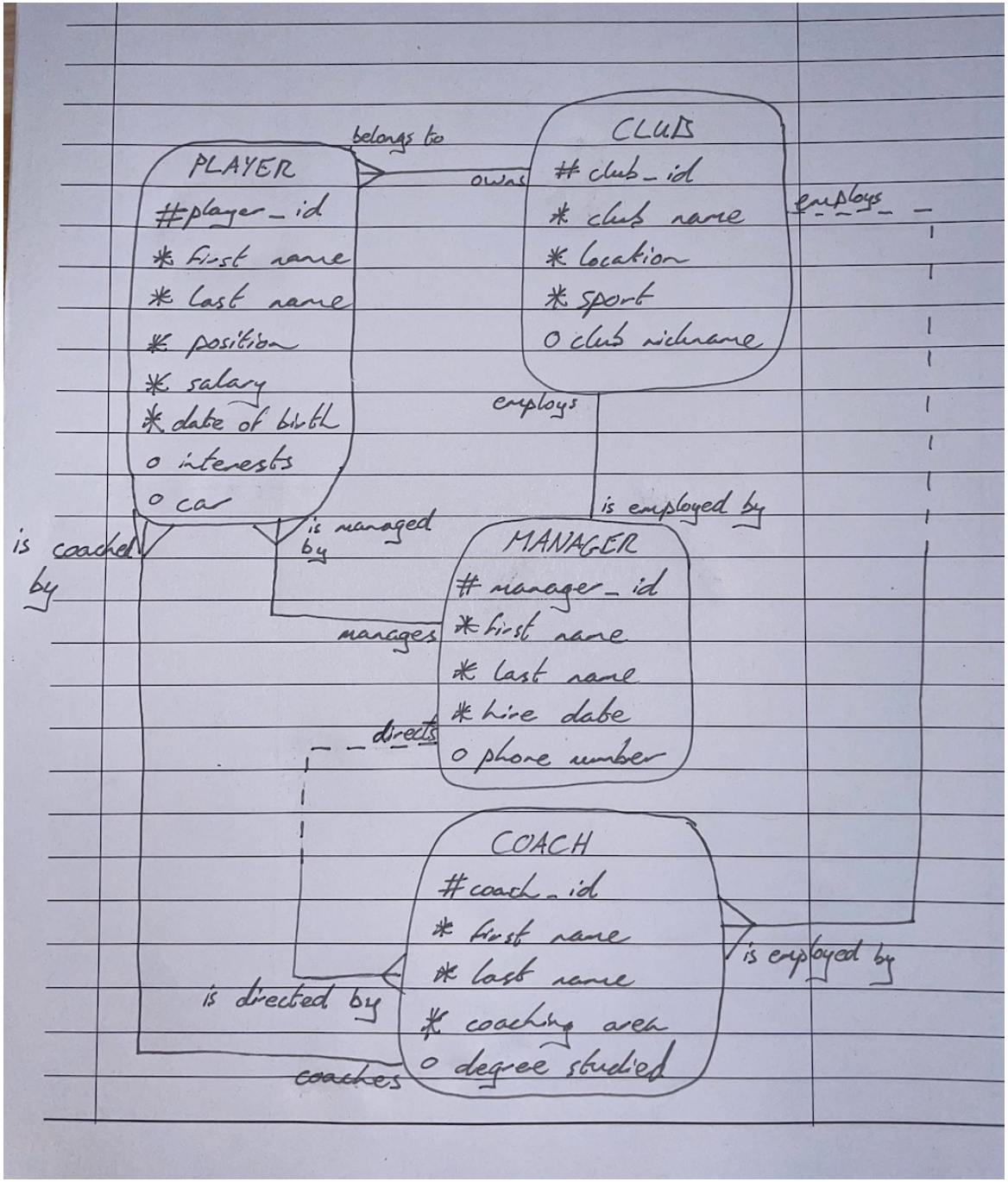
Attendance

Check-In is currently running .
Students can check in until check in period closes or is ended.

3 5 3 0

M:M Resolution Example Cleaning Services



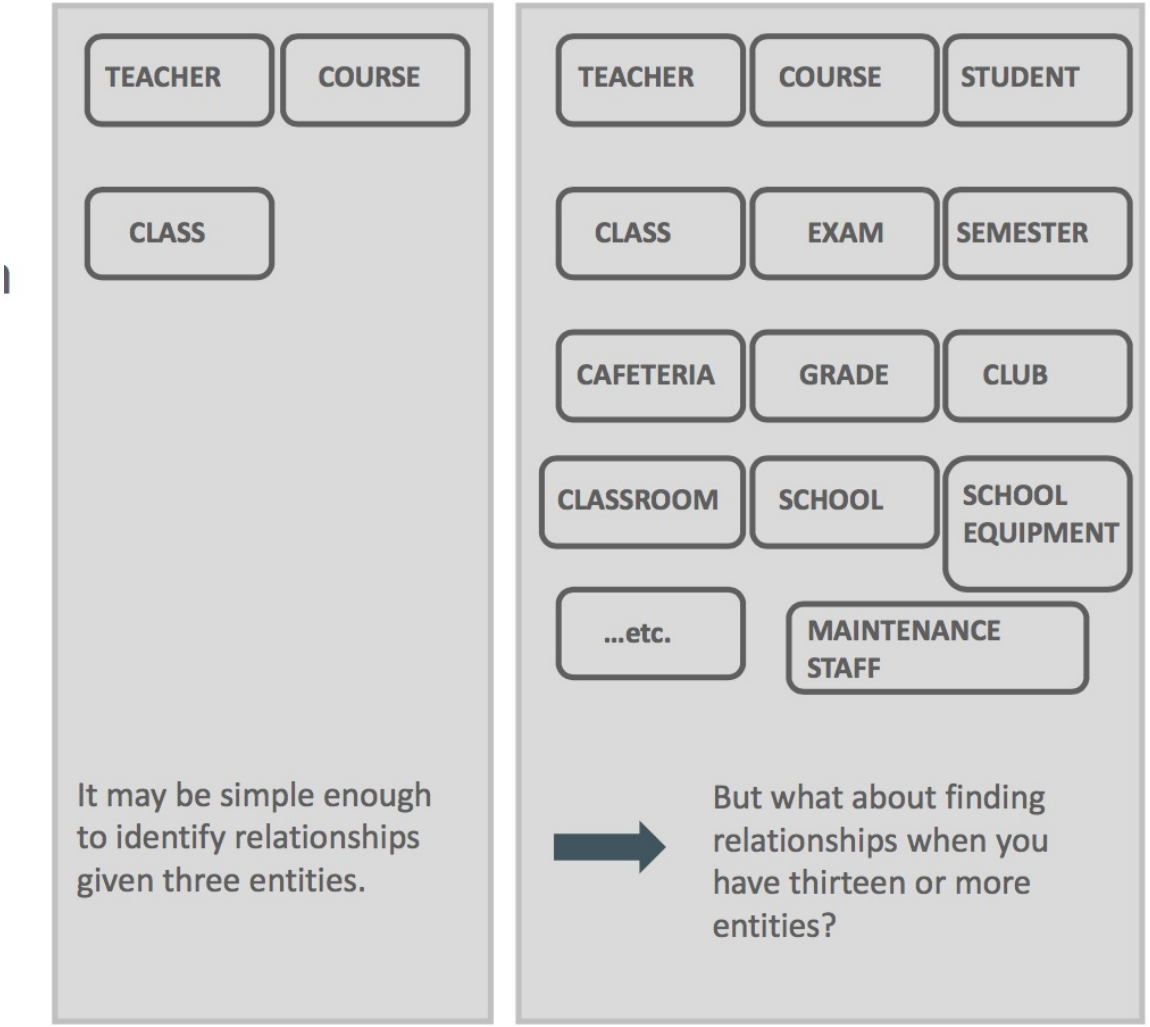

belongs to
owns
PLAYER
#player_id
* first name
* last name
* position
* salary
* date of birth
o interests
o car
CLUB
club_id
* club name
* location
* sport
o club nickname
employs
employs
is employed by
is managed by
is coached by
MANAGER
manager_id
* first name
* last name
* hire date
o phone number
manages
directs
COACH
coach_id
* first name
* last name
* coaching area
o degree studied
is directed by
is employed by
coaches

Kevin Byrne

Matrix Diagrams

- It is useful to know more than one way to discover relationships.
- Using a matrix diagram, especially when you are dealing with many entities, is a good way to make sure that you haven’t missed any relationships.

Matrix Diagrams



Business Scenario

- "I work for a travel agency. I keep a record of the countries that our customers have visited and the landmarks they've seen in each country. It helps us customize tours for them."
- We can use the matrix diagram to uncover relationships.

	TRAVELER	COUNTRY	LANDMARK
TRAVELER			
COUNTRY			
LANDMARK			

MATRIX DIAGRAM

Matrix Diagrams

To avoid confusion, be consistent in writing to and reading from the matrix only in one direction.

	TRAVELER	COUNTRY	LANDMARK
TRAVELER		visit	have seen
COUNTRY	visited by		the location of
LANDMARK	seen by	located in	

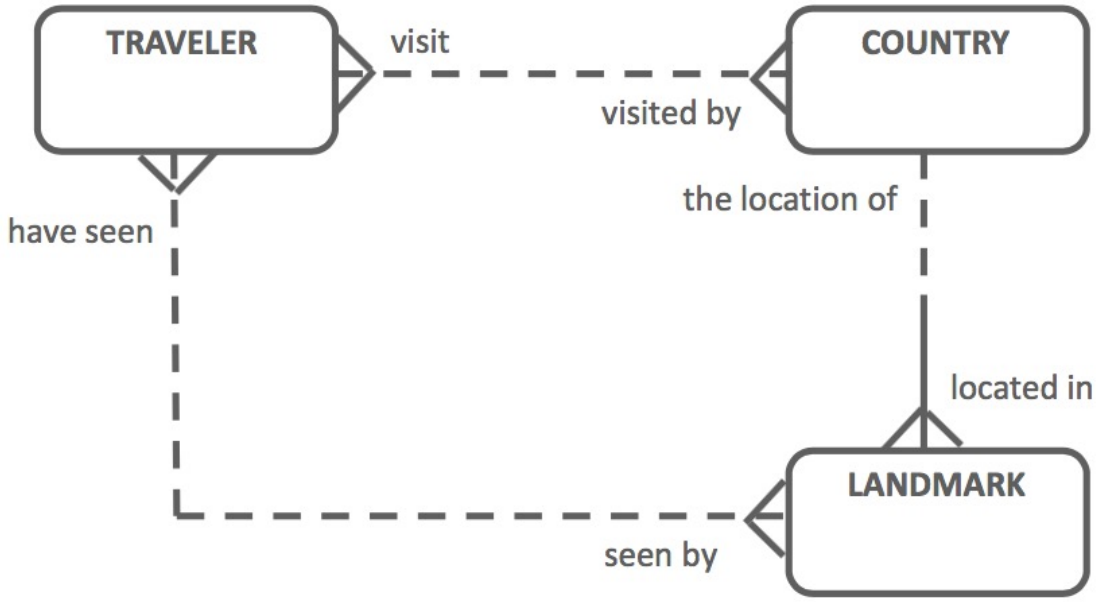
correct: COUNTRY visited by TRAVELER
correct: LANDMARK seen by TRAVELER

incorrect: TRAVELER visited by COUNTRY
incorrect: TRAVELER seen by LANDMARK

Matrix Diagrams

- Relationships discovered via the matrix diagram are then drawn on the ERD.
- Matrix diagrams do not show optionality and cardinality.

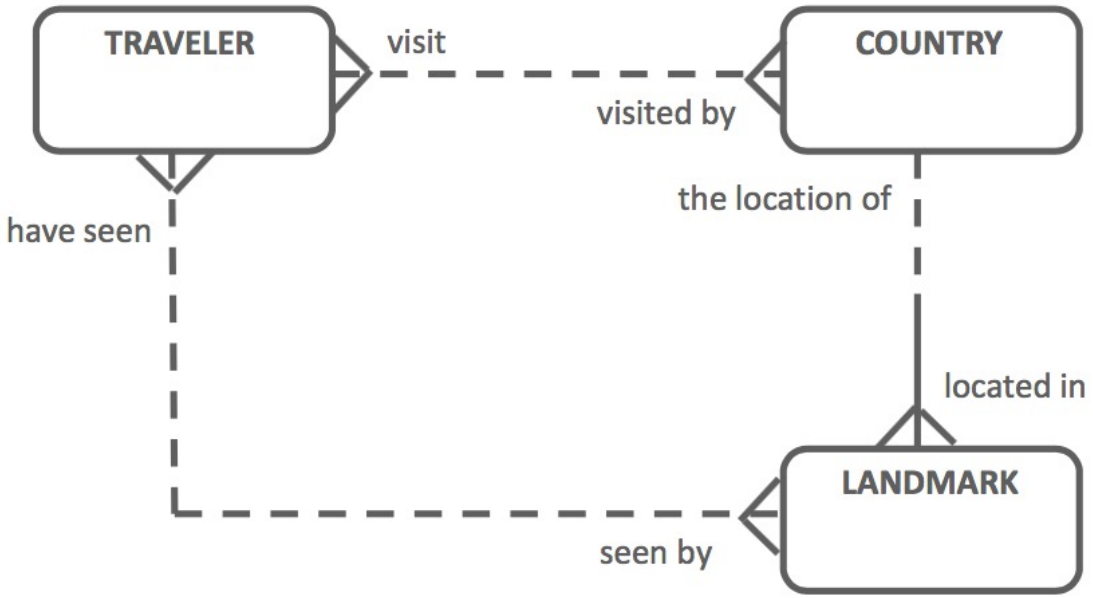
	TRAVELER	COUNTRY	LANDMARK
TRAVELER		visit	have seen
COUNTRY	visited by		the location of
LANDMARK	seen by	located in	



Matrix Diagrams

- Each COUNTRY may be visited by one or more TRAVELERs.
- Each TRAVELER may visit one or more COUNTRY.

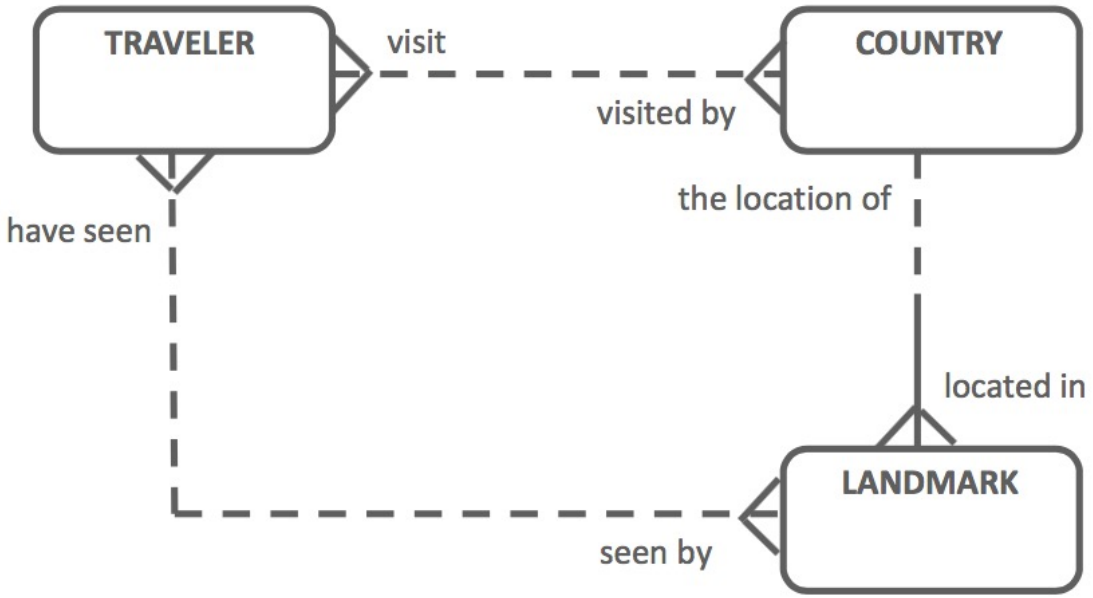
	TRAVELER	COUNTRY	LANDMARK
TRAVELER		visit	have seen
COUNTRY	visited by		the location of
LANDMARK	seen by	located in	



Matrix Diagrams

- Each COUNTRY may be visited by one or more TRAVELERs.
- Each TRAVELER may visit one or more COUNTRY.

	TRAVELER	COUNTRY	LANDMARK
TRAVELER		visit	have seen
COUNTRY	visited by		the location of
LANDMARK	seen by	located in	

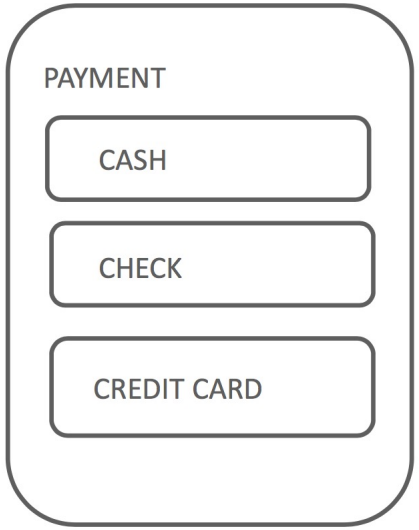


Purpose of Supertypes/Subtypes

- Supertypes and subtypes occur frequently in the real world:
- food order types (dine in, take away, online orders)
- grocery bag types (paper, plastic)
- payment types (check, cash, credit)

Evaluating Entities

- Often some instances of an entity have attributes and/or relationships that other instances do not have.
- Imagine a business which needs to track payments from customers.
- Customers can pay by cash, by check, or by credit card.



Evaluating Entities

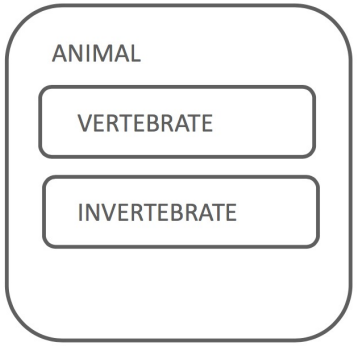
- All payments have some common attributes: payment date, payment amount, and so on.
- But only credit cards would have a “card number” attribute.
- And for credit card and check payments, we may need to know which CUSTOMER made the payment, while this is not needed for cash payments.

Evaluating Entities

- Should we create a single PAYMENT entity or three separate entities CASH, CHECK, and CREDIT CARD?
- And what happens if in the future we introduce a fourth method of payment?

Subdivide an Entity

- Sometimes it makes sense to subdivide an entity into subtypes.
- This may be the case when a group of instances has special properties, such as attributes or relationships that exist only for that group.
- In this case, the entity is called a “supertype” and each group is called a “subtype”.

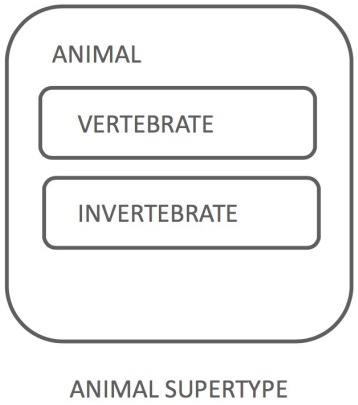


ANIMAL SUPERTYPE

Subtype Characteristics

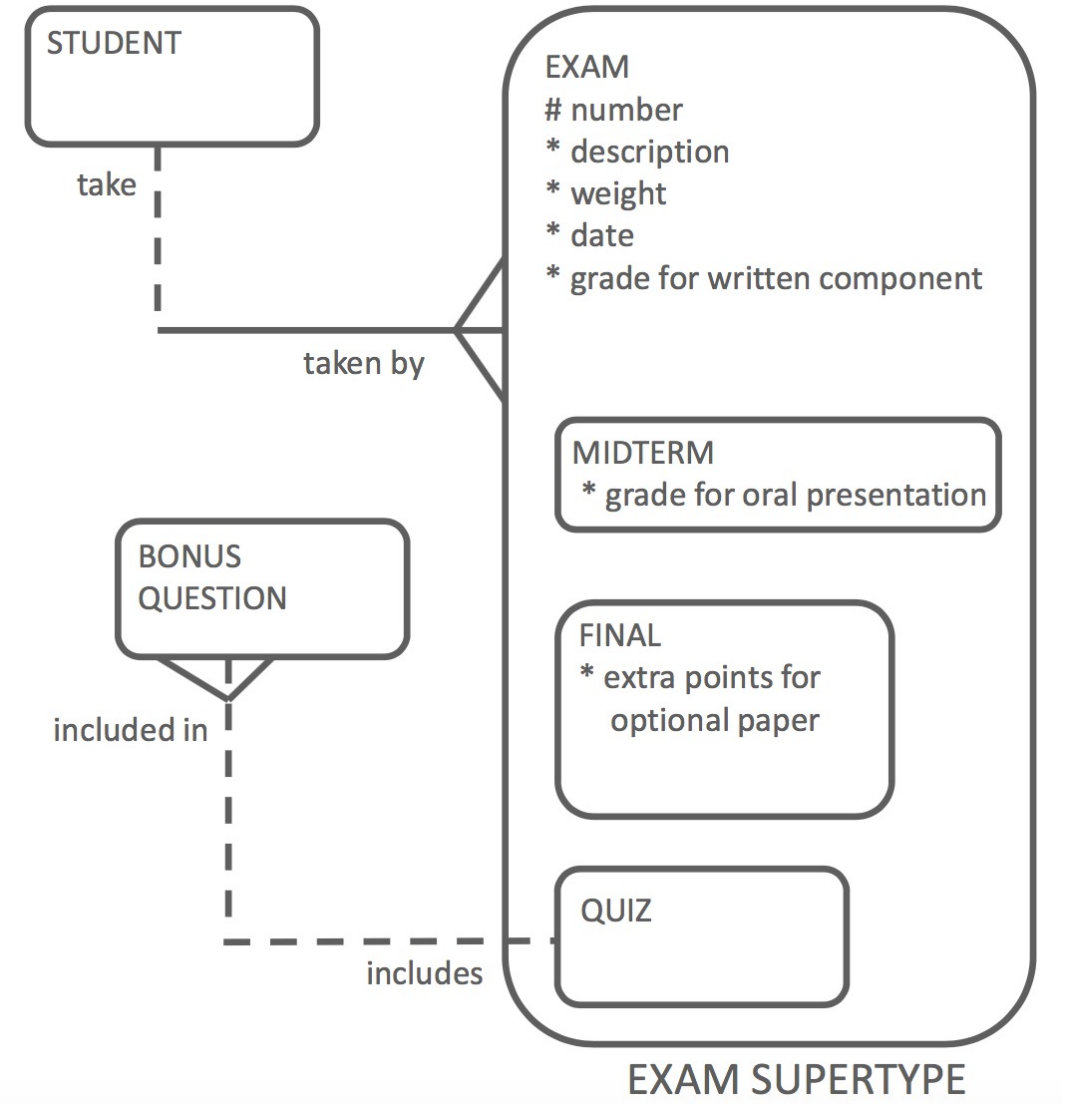
A subtype:

- Inherits all attributes of the supertype
- Inherits all relationships of the supertype
- Usually has its own attributes or relationships
- Is drawn within the supertype
- Never exists alone
- May have subtypes of its own



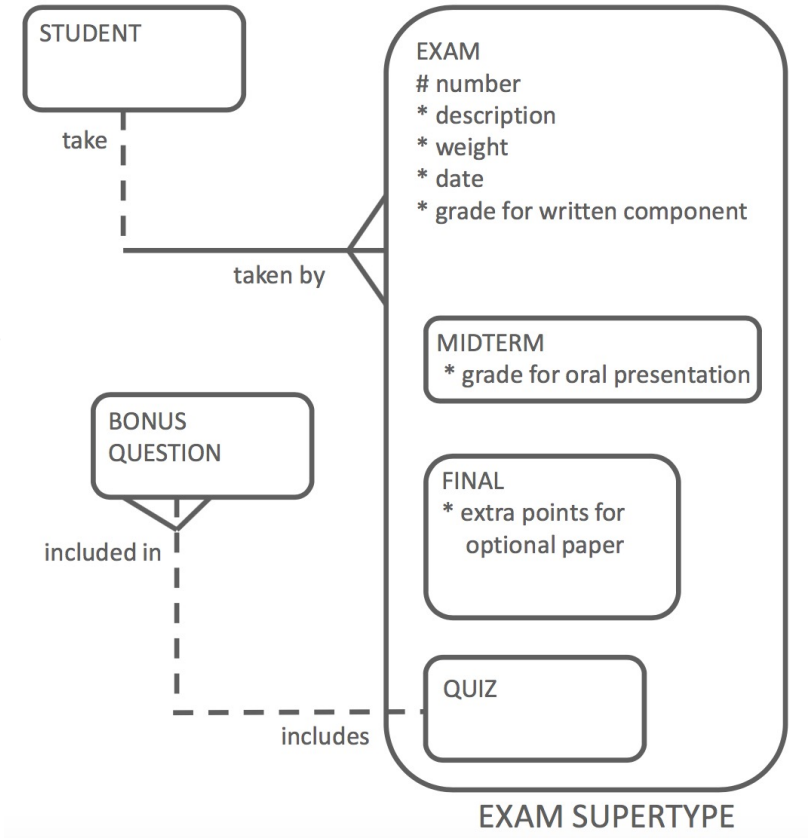
ANIMAL SUPERTYPE

SuperType Example



SuperType Example

- The same applies to relationships.
- Subtypes inherit all attributes and relationships of the supertype entity.

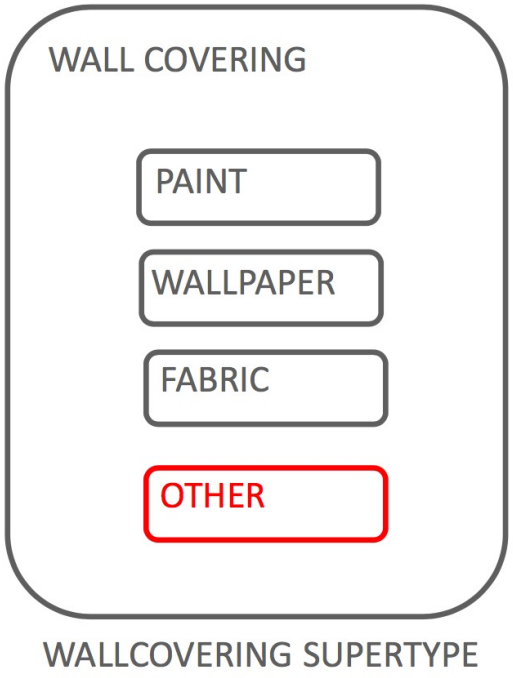


Always More Than One Subtype

- When an ER model is complete, subtypes never stand alone. In other words, if an entity has a subtype, a second subtype must also exist. This makes sense.
- A single subtype is exactly the same as the supertype.
- This idea leads to the two subtype rules:
  - Exhaustive: Every instance of the supertype is also an instance of one of the subtypes. All subtypes are listed without omission.
  - Mutually Exclusive: Each instance of a supertype is an instance of only one possible subtype.

Always More Than One Subtype

- At the conceptual modeling stage, it is good practice to include an OTHER subtype to make sure that your subtypes are exhaustive -- that you are handling every instance of the supertype.

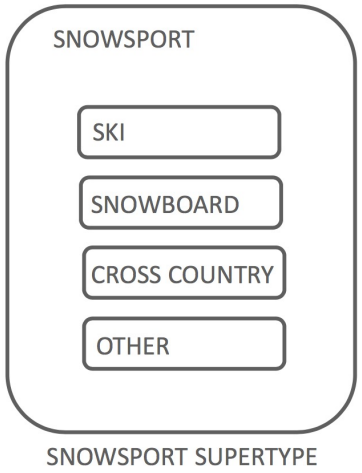


Subtypes always Exists

- Any entity can be subtyped by making up a rule that subdivides the instances into groups.
- But being able to subtype is not the issue—having a reason to subtype is the issue.
- When a need exists within the business to show similarities and differences between instances, then subtype.

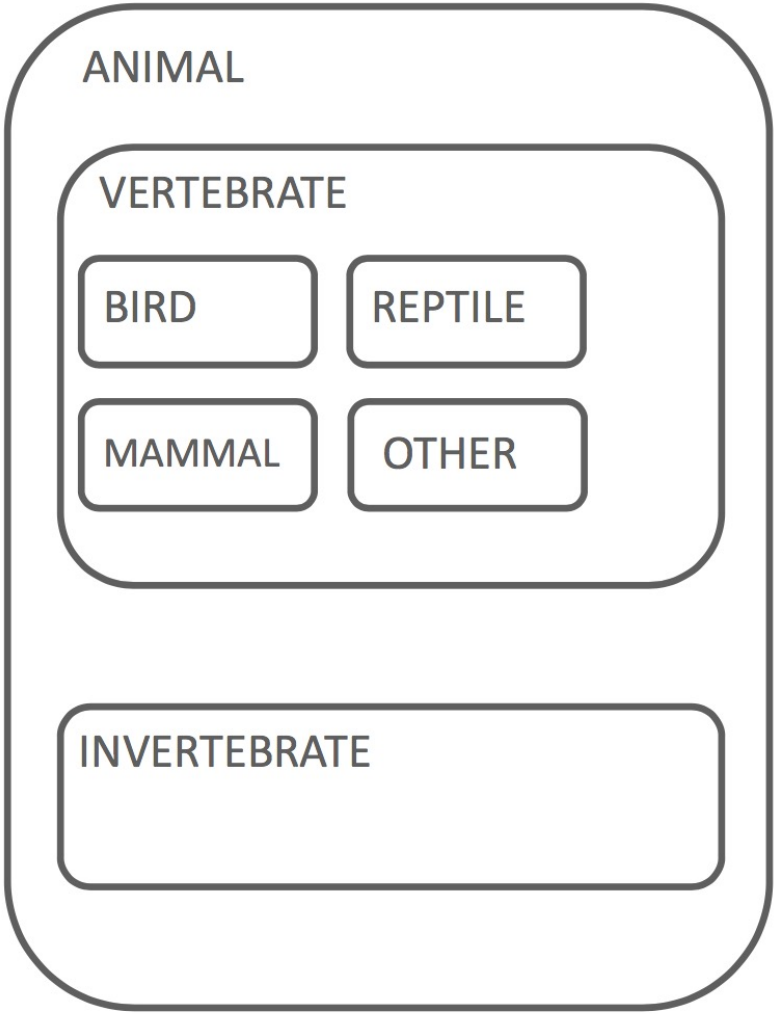
Correctly Identifying Subtypes

- When modeling supertypes and subtypes, you can use three questions to see if the subtype is correctly identified:
- Is this subtype a kind of supertype?
- Have I covered all possible cases? (exhaustive)
- Does each instance fit into one and only one subtype? (mutually exclusive)



Nested Subtypes

- You can nest subtypes.
- For ease of reading -- "readability" -- you would usually show subtypes with only two levels, but there is no rule that would stop you from going beyond two levels.



NESTED ANIMAL SUPERTYPE