Constraints & cardinality

23 September 2023 20:29

Binary relationship constraints

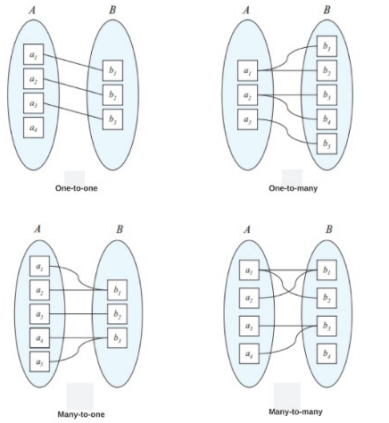
1. Cardinality ratio
2. Participation constraints and existence dependencies

Structural constraints = green

Cardinality Ratio

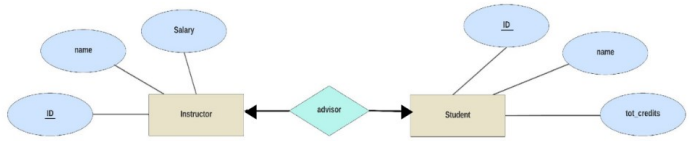
Number of entities to which another entity can be associated via relationship set

- Binary relationship set R between entity sets A and B, the possible mapping cardinality are:
  - One-to-one
  - One-to-many
  - Many-to-one
  - Many-to-many



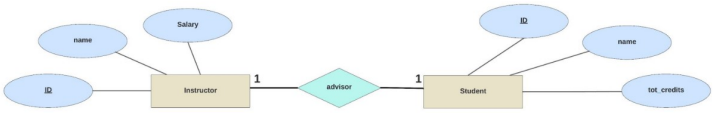
One-to-one

- We draw a directed line from the relationship set to both entity sets.
- For example, the directed lines to instructor and student indicate that an instructor may advise at most one student, and a student may have at most one advisor.



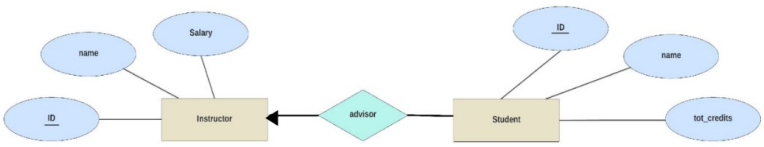
One-to-one (1:1)

- the above representation can also be shown as



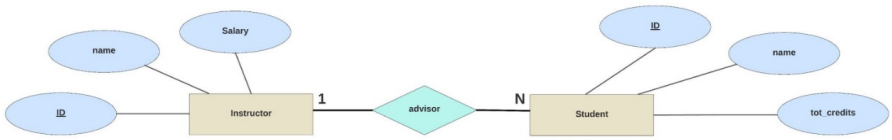
One-to-many

- We draw a directed line from the relationship set to the "one" side of the relationship.
- Thus, there is a directed line from relationship-set advisor to the entity-set instructor, and an undirected line to the entity set student.
- This indicates that an instructor may advise many students, but a student may have at most one advisor.

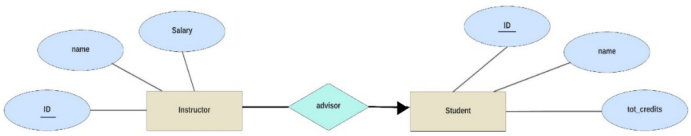


One-to-many (1:N)

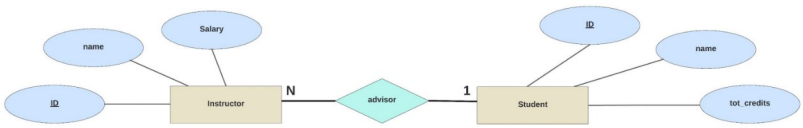
- the above representation can also be denoted as



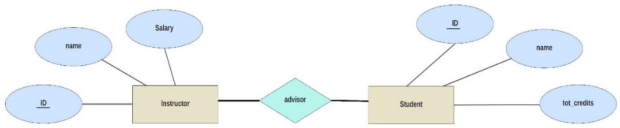
Many-to-one
- The converse of the before type
- This indicates that an instructor may advise at most one student, but a student may have many advisors.



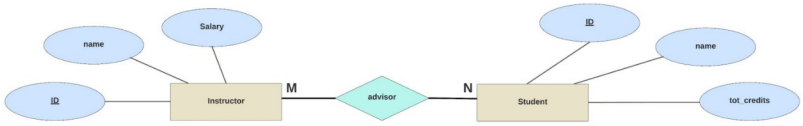
Many-to-one (N:1)
- the above representation can also be denoted as



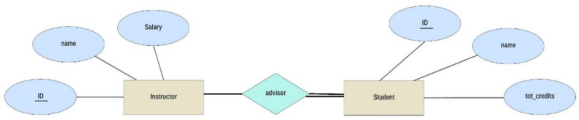
Many-to-many
- We draw an undirected line from the relationship set to both entity sets.
- Thus, there are undirected lines from the relationship set advisor to both entity sets instructor and student.
- This indicates that an instructor may advise many students and a student may have many advisors.



Many-to-many (M:N)
- the above representation can also be denoted as



- We indicate the total participation of an entity in a relationship set using double lines.
- The example of the advisor relationship set described in the previous slide would look as shown
- where the double line indicates that a student must have an advisor.

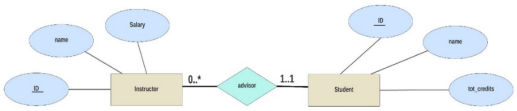


Total participation: Every entity in E must participate in at least 1 relationship in R, double line
Partial participation: It is possible that some entities E do not participate in R.

- E-R diagrams also provide a way to indicate more complex constraints on the number of times each entity participates in relationships in a relationship set.
- A line may have an associated minimum and maximum cardinality, shown in the form **l..h**
  - **l** is the **minimum cardinality**
  - **h** is the **maximum cardinality**.

- A minimum value = 1 □ total participation of the entity set in the relationship set;
- A maximum value = 1 □ that the entity participates in at most one relationship,
- A maximum value = * indicates **no limit**.

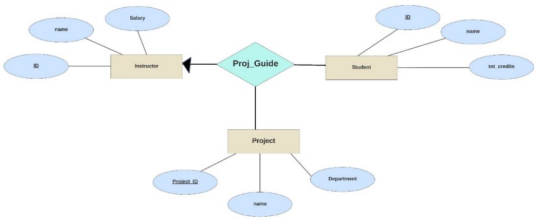
- Could you try interpreting what would this mean



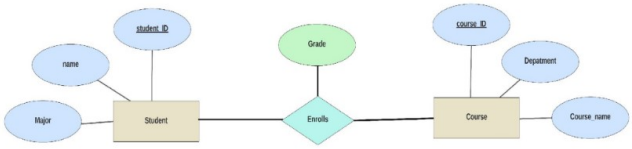
- The interpretation would be:
  - The line between advisor and student has a cardinality constraint of 1..1, meaning the minimum and the maximum cardinality are both 1. That is, **each student must have exactly one advisor.**
  - The limit 0.. ∗ on the line between advisor and instructor indicates that an instructor can have zero or more students. Thus, the **relationship advisor is one-to-many from instructor to student**,
  - further the **participation of student in advisor is total**, implying that a student must have an advisor.

- In the case of nonbinary relationship sets, we can specify some types of many-to-one relationships.
- For example, A student can have at most one instructor as a guide on a project.
  - This constraint can be specified by an arrow pointing to instructor on the edge from proj guide.

- We permit at most one arrow out of a nonbinary relationship set, since an E-R diagram with two or more arrows out of a nonbinary relationship set can be interpreted in two ways.



- The primary key for the advisor relation :
  - {primary-key(Student) ∪ primary-key(Course)}
  - {Student_ID, Course_ID}
  - The advisory relation : {Student_ID, Course_ID, Grade}
  - Note that grade is not a part of the primary key



PK of relation

One-to-Many or Many-to-One

- the primary key of the "many" side is a minimal superkey and is used as the primary key.

- For example, if the advisor relationship is many-to-one from student to instructor, that is, each student can have at most one advisor
  - then the primary key of advisor is simply the primary key of student.

- On the contrary, if an instructor can advise only one student, that is, if the advisor relationship is many-to-one from instructor to student
  - then the primary key of advisor is simply the primary key of instructor.

One-to-One

- For this type of relation, the primary key of either one of the participating entity sets forms a minimal superkey, and either one can be chosen as the primary key of the relationship set.
- Let us consider the situation:
- If an instructor can advise only one student, and each student can be advised by only one instructor, that is, if the advisor relationship is one-to-one
  - then the primary key of either student or instructor can be chosen as the primary key for the advisor.

Non Binary Relationships

- So as discussed above, what would be the different ways in which multiple arrows out of a relationship could be interpreted

- Suppose there is a relationship set R between entity sets E1, E2, E3, E4, and the only arrows are on the edges to entity sets E3 and E4. Then, the two possible interpretations are:
  - A particular combination of entities from E1, E2 can be associated with at most one combination of entities from E3, E4.
    - ➢ The primary key for the relationship R: The union of the primary keys of E1 and E2.
  - A particular combination of entities from E1, E2, E3 can be associated with at most one combination of entities from E4, and further a particular combination of entities from E1, E2, E4 can be associated with at most one combination of entities from E3
    - ➢ The union of the primary keys of E1, E2, and E3 forms a candidate key,
    - ➢ The union of the primary keys of E1, E2, and E4 forms a candidate key

- In order to represent a situation where one of the multiple-arrow situations holds,

Technique 1:
- the E-R design can be modified by replacing the non-binary relationship set with an entity set.
- That is, we treat each instance of the non-binary relationship set as an entity. Then we can relate each of those entities to corresponding instances of E1, E2, E4 via separate relationship sets.

Technique 2:
- We can make use of functional dependencies.
- Functional dependencies which allow either of these interpretations to be specified simply in an unambiguous manner.

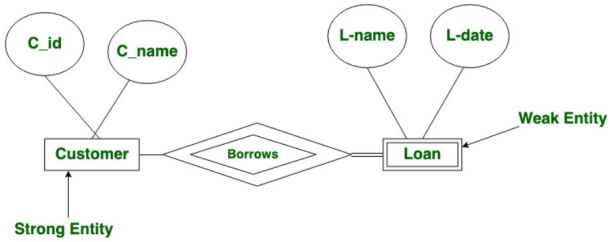
- The primary key for the relationship set R is then the union of the primary keys of those participating entity sets Ei that do not have an incoming arrow from the relationship set R.

Weak Entity

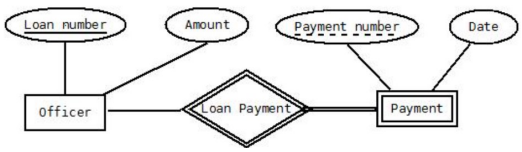
The entity sets which do not have sufficient attributes to form a primary key are known as **weak entity sets** and the entity sets which have a primary key are known as strong entity sets.

- As the weak entities do not have any primary key, they cannot be identified on their own, so they depend on some other entity (known as owner entity).
- The weak entities have total participation constraint (existence dependency) in its identifying relationship with owner identity.
- Weak entity types have partial keys. Partial Keys are set of attributes with the help of which the tuples of the weak entities can be distinguished and identified.

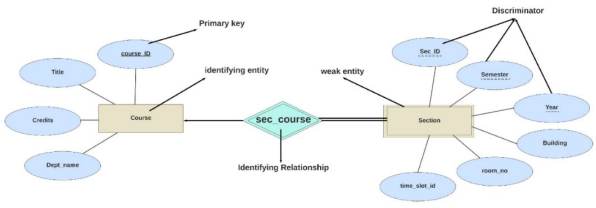
Weak entity is **depend on strong entity** to ensure the existence of weak entity. Like strong entity, weak entity does not have any primary key, It has partial discriminator key. Weak entity is represented by double rectangle. The relation between one strong and one weak entity is represented by double diamond.



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



- Note that the ER diagram for the same would be as follows:
  - a weak entity set is depicted via a double rectangle
  - discriminator is underlined with a dashed line.
  - The relationship set connecting the weak entity set to the identifying strong entity set is depicted by a double diamond.



- Note that we could have chosen to make sec_id globally unique across all courses offered in the university, in which case the section entity set would have had a primary key.
- However, conceptually, a section is still dependent on a course for its existence, which is made explicit by making it a weak entity set.

- **In general, a weak entity set must have total participation in its identifying relationship set, and the relationship is many-to-one toward the identifying entity set.**

- A weak entity set can participate in relationships other than the identifying relationship.
  - For instance, the section entity could participate in a relationship with the time slot entity set, identifying the time when a particular class section meets.

- A weak entity set may participate as an owner in an identifying relationship with another weak entity set.
- It is also possible to have a weak entity set with more than one identifying entity set. A particular weak entity would then be identified by a combination of entities, one from each identifying entity set.
- The primary key of the weak entity set would consist of the union of the primary keys of the identifying entity sets, plus the discriminator of the weak entity set.