

CSCD 327: Relational Database Systems

Entity-relationship model (Part I)

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Modeling

- A *database* can be modeled as:
 - a collection of entities,
 - relationship among entities.
- An **entity** is an object that exists and is distinguishable from other objects.
 - Example: specific person, company, event, plant
- Entities have **attributes**
 - Example: people have *names* and *addresses*
- An **entity set** is a set of entities of the same type that share the same properties.
 - Example: set of all persons, companies, trees, holidays

Entity Sets *instructor* and *student*

instructor_ID instructor_name

76766	Crick
45565	Katz
10101	Srinivasan
98345	Kim
76543	Singh
22222	Einstein

instructor

student-ID student_name

98988	Tanaka
12345	Shankar
00128	Zhang
76543	Brown
76653	Aoi
23121	Chavez
44553	Peltier

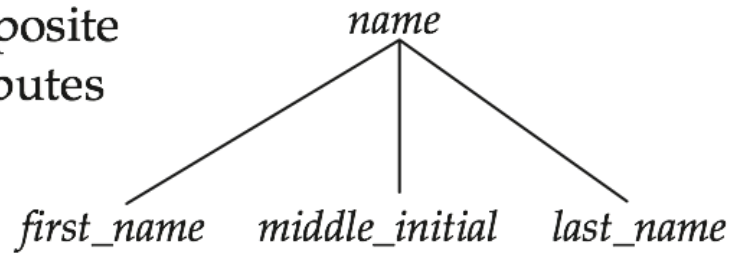
student

Attributes

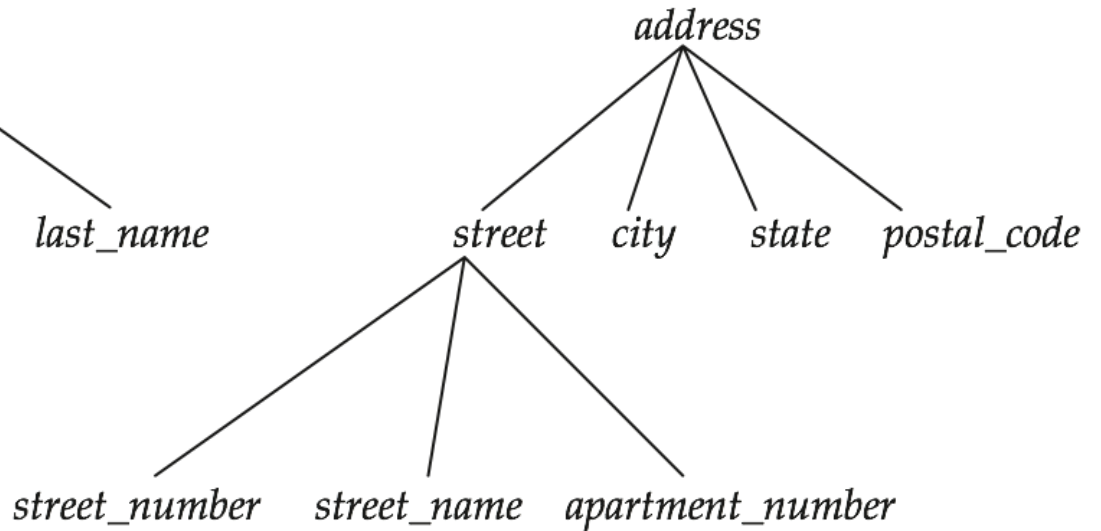
- An entity is represented by a set of attributes, that is descriptive properties possessed by all members of an entity set.
 - Example:
instructor = (ID, name, street, city, salary)
course = (course_id, title, credits)
- **Domain** – the set of permitted values for each attribute
- Attribute types:
 - **Simple** and **composite** attributes.
 - **Single-valued** and **multivalued** attributes
 - Example: multivalued attribute: *phone_numbers*
 - **Derived** attributes
 - Can be computed from other attributes
 - Example: age, given date_of_birth

Composite Attributes

composite
attributes



component
attributes



Relationship Sets

- A **relationship** is an association among several entities

Example:

44553 (Peltier) advisor 22222 (Einstein)
student entity relationship set *instructor* entity

- A **relationship set** is a mathematical relation among $n \geq 2$ entities, each taken from entity sets

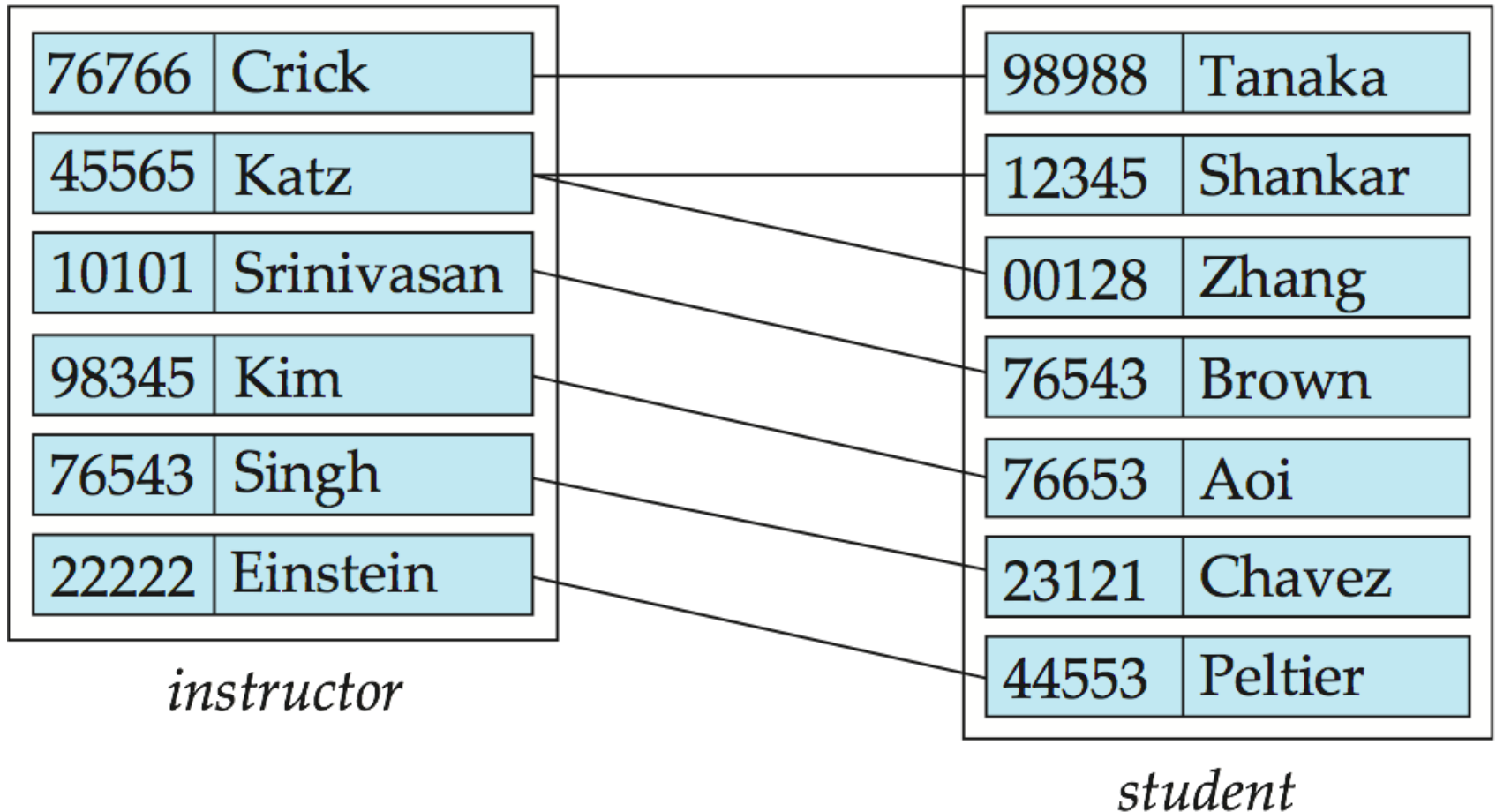
$$\{(e_1, e_2, \dots, e_n) \mid e_1 \in E_1, e_2 \in E_2, \dots, e_n \in E_n\}$$

where (e_1, e_2, \dots, e_n) is a relationship

– Example:

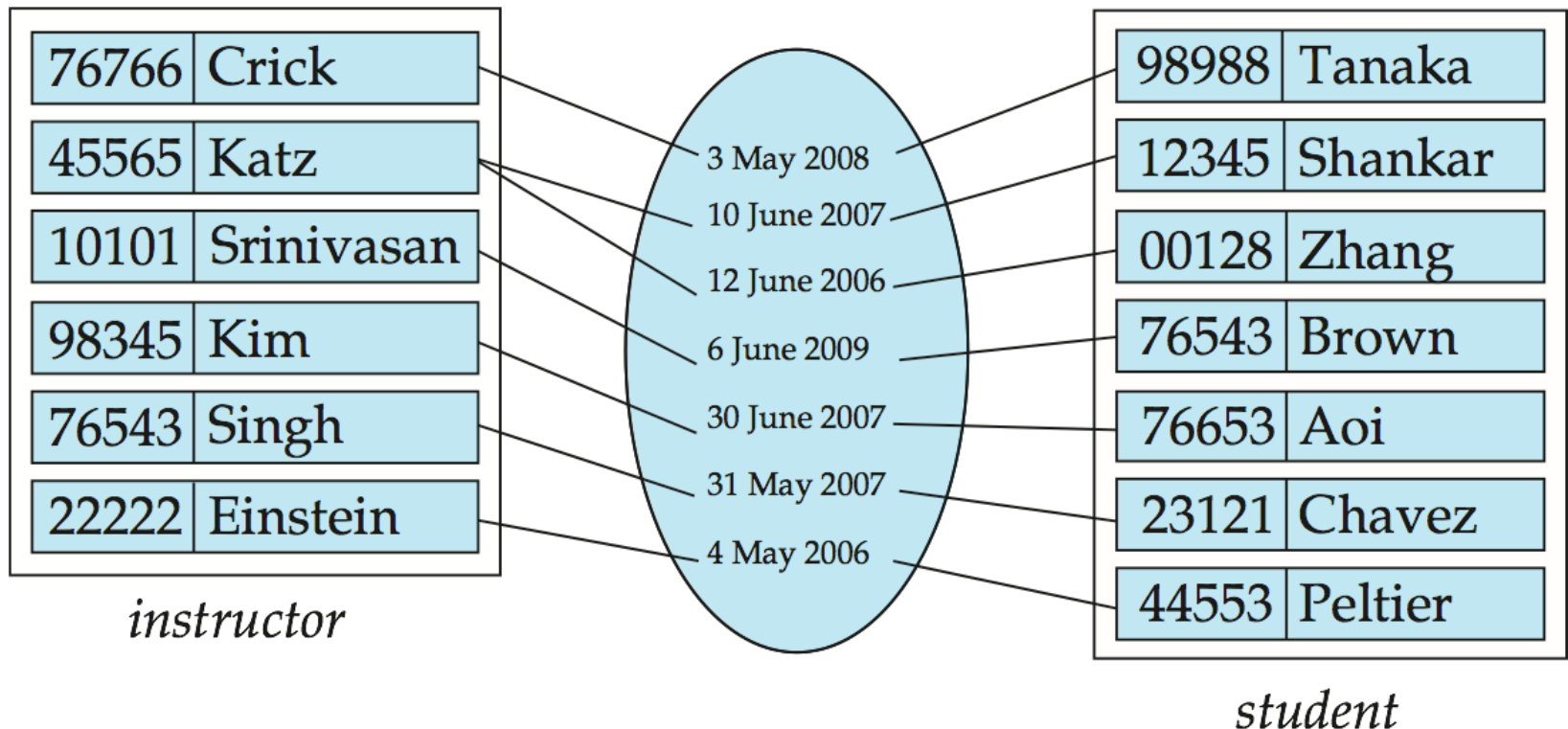
$$(44553, 22222) \in \text{advisor}$$

Relationship Set *advisor*



Relationship Sets (Cont.)

- An **attribute** can also be property of a relationship set.
- For instance, the *advisor* relationship set between entity sets *instructor* and *student* may have the attribute *date* which tracks when the student started being associated with the advisor



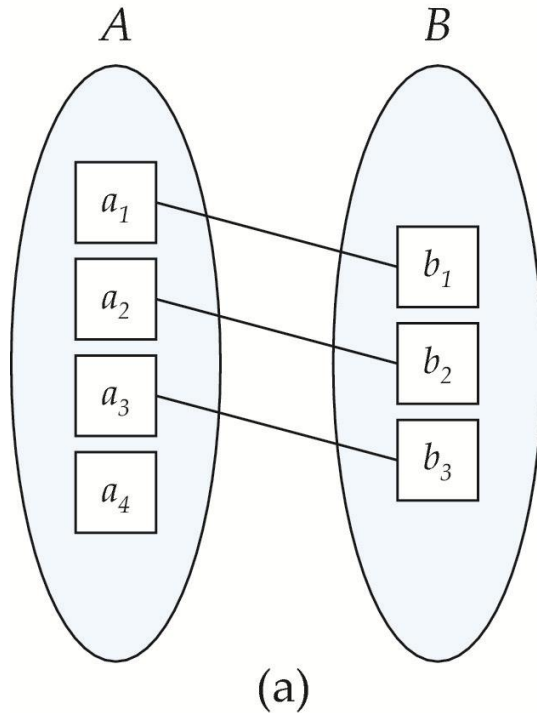
Degree of a Relationship Set

- **binary relationship**
 - involve two entity sets (or degree two).
 - most relationship sets in a database system are binary.
- Relationships between more than two entity sets are rare. Most relationships are binary. (More on this later.)
 - ▶ Example: *students* work on research *projects* under the guidance of an *instructor*.
 - ▶ relationship *proj_guide* is a ternary relationship between *instructor*, *student*, and *project*

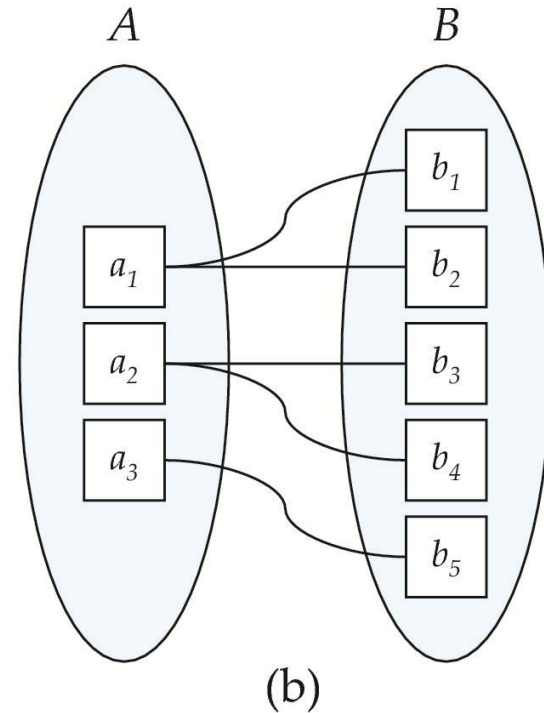
Mapping Cardinality Constraints

- Express the number of entities to which another entity can be associated via a relationship set.
- Most useful in describing binary relationship sets.
- For a binary relationship set the mapping cardinality must be one of the following types:
 - One to one
 - One to many
 - Many to one
 - Many to many

Mapping Cardinalities



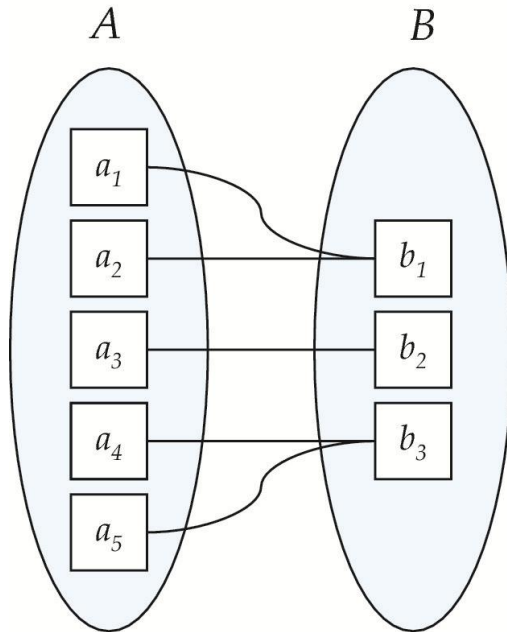
One to one



One to many

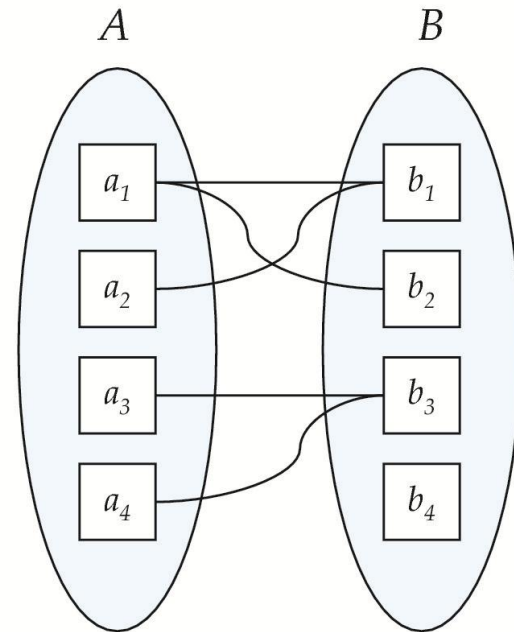
Note: Some elements in A and B may not be mapped to any elements in the other set

Mapping Cardinalities



(a)

Many to one



(b)

Many to many

Note: Some elements in A and B may not be mapped to any elements in the other set

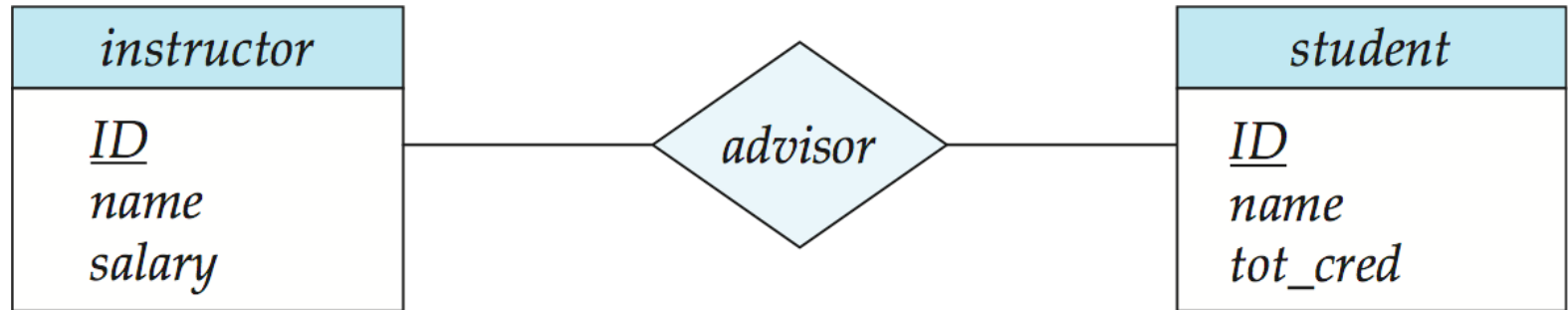
Keys

- A **super key** of an entity set is a set of one or more attributes whose values uniquely determine each entity.
- A **candidate key** of an entity set is a minimal super key
 - *ID* is candidate key of *instructor*
 - *course_id* is candidate key of *course*
- Although several candidate keys may exist, one of the candidate keys is selected to be the **primary key**.

Keys for Relationship Sets

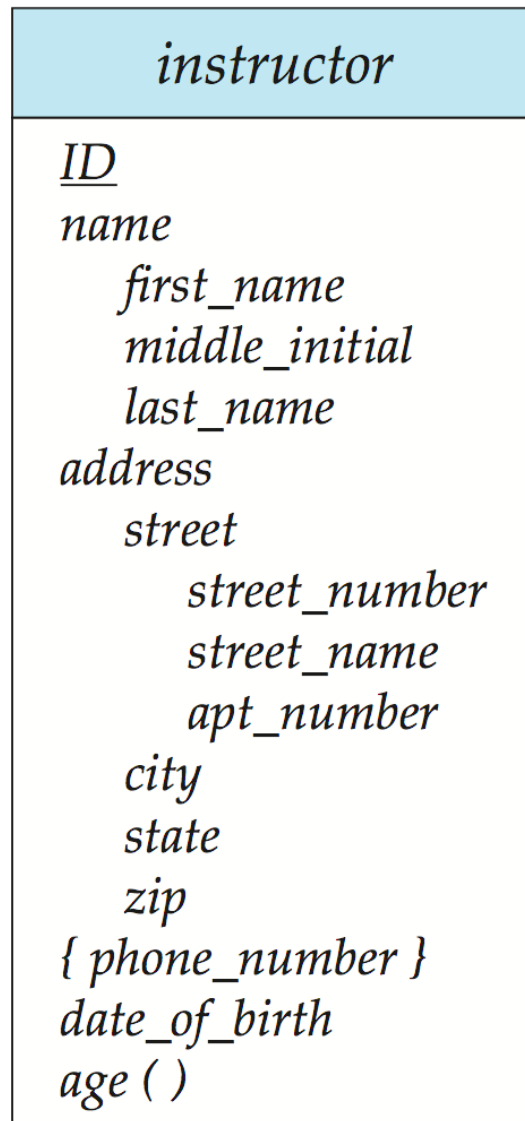
- The combination of primary keys of the participating entity sets forms a super key of a relationship set.
 - (s_id, i_id) is the super key of *advisor*
 - *NOTE: this means **a pair of entity sets can have at most one relationship in a particular relationship set.***
 - Example: if we wish to track multiple meeting dates between a student and her advisor, we cannot assume a relationship for each meeting. We can use a multivalued attribute though
- Must consider the mapping cardinality of the relationship set when deciding what are the candidate keys
- Need to consider semantics of relationship set in selecting the *primary key* in case of more than one candidate key

E-R Diagrams

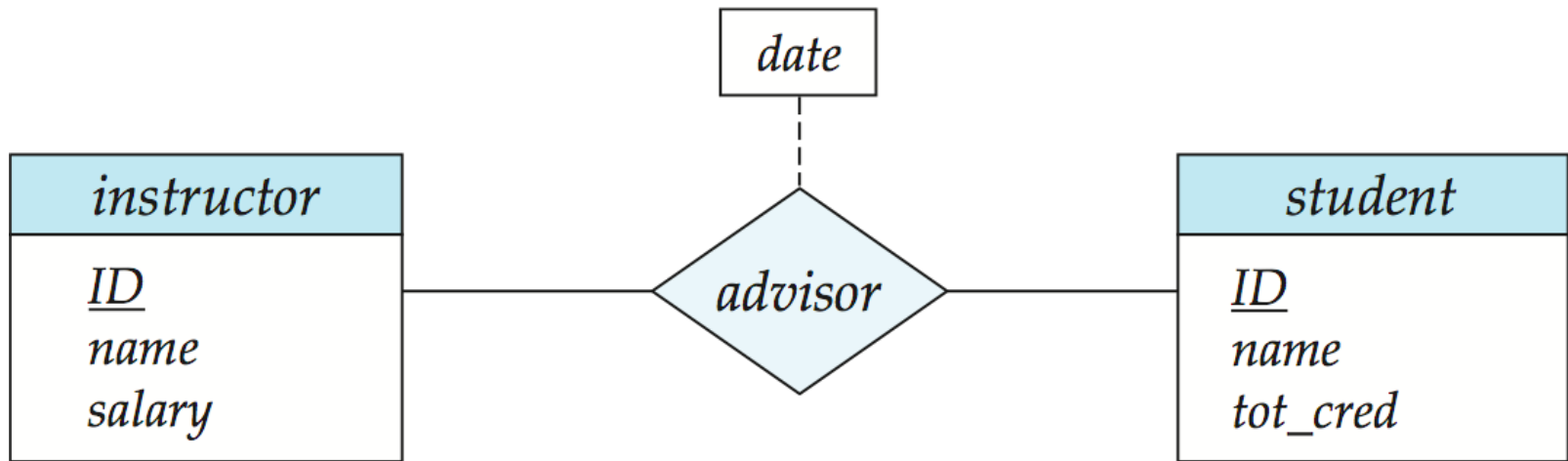


- Rectangles represent entity sets.
- Diamonds represent relationship sets.
- Attributes listed inside entity rectangle
- Underline indicates primary key attributes

Entity With Composite, Multivalued, and Derived Attributes

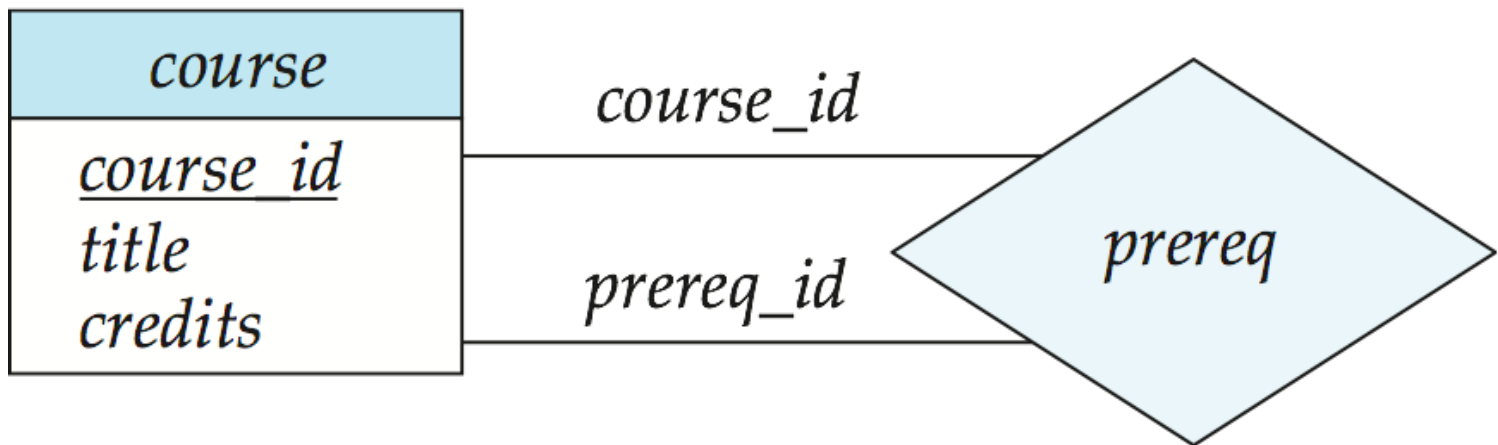


Relationship Sets with Attributes



Roles

- Entity sets of a relationship need not be distinct
 - Each occurrence of an entity set plays a “role” in the relationship
- The labels “*course_id*” and “*prereq_id*” are called **roles**.

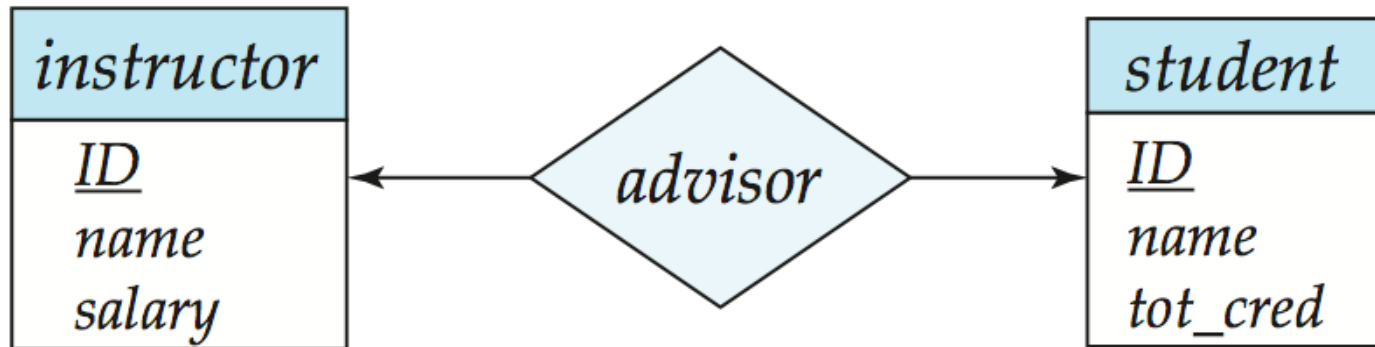


Cardinality Constraints

- We express cardinality constraints by drawing either a directed line (\rightarrow), signifying “one,” or an undirected line ($-$), signifying “many,” between the relationship set and the entity set.
- One-to-one relationship:
 - A student is associated with at most one *instructor* via the relationship *advisor*
 - A *student* is associated with at most one *department* via *stud_dept*

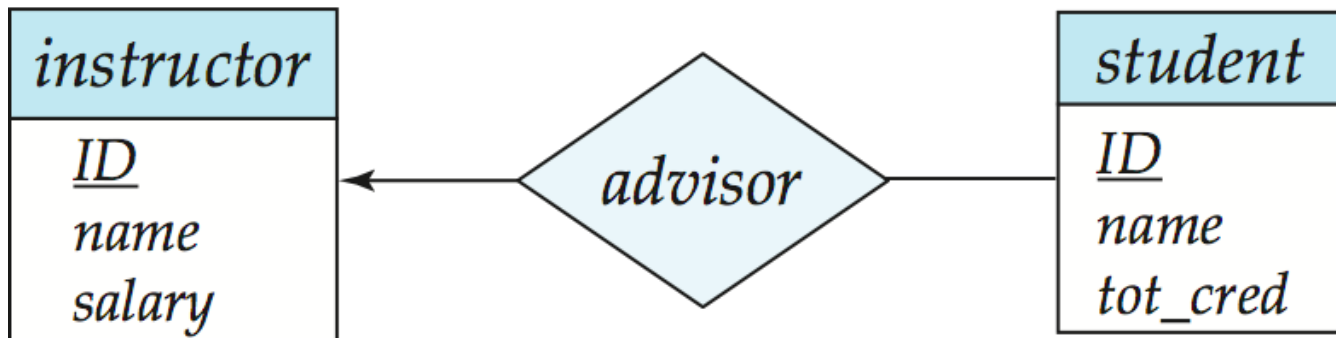
One-to-One Relationship

- one-to-one relationship between an *instructor* and a *student*
 - an instructor is associated with at most one student via *advisor*
 - and a student is associated with at most one instructor via *advisor*



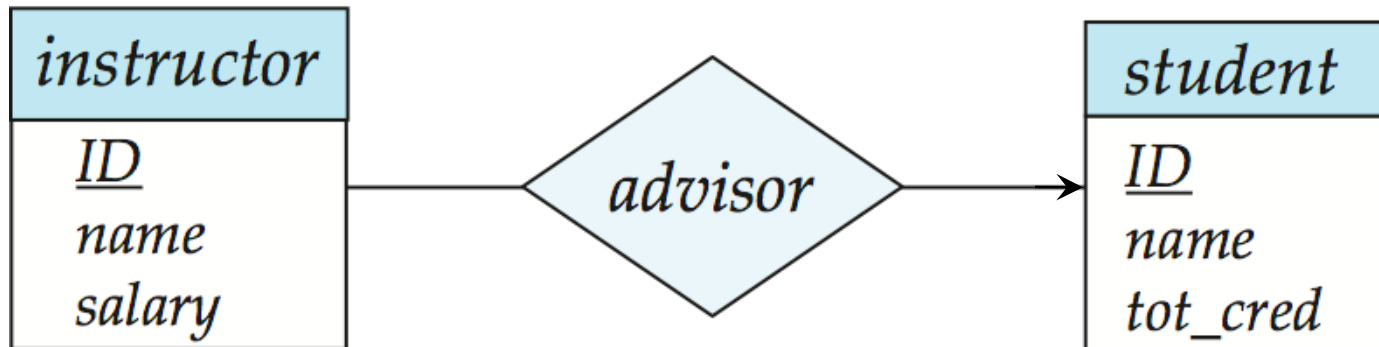
One-to-Many Relationship

- one-to-many relationship between an *instructor* and a *student*
 - an instructor is associated with several (including 0) students via *advisor*
 - a student is associated with at most one instructor via advisor,



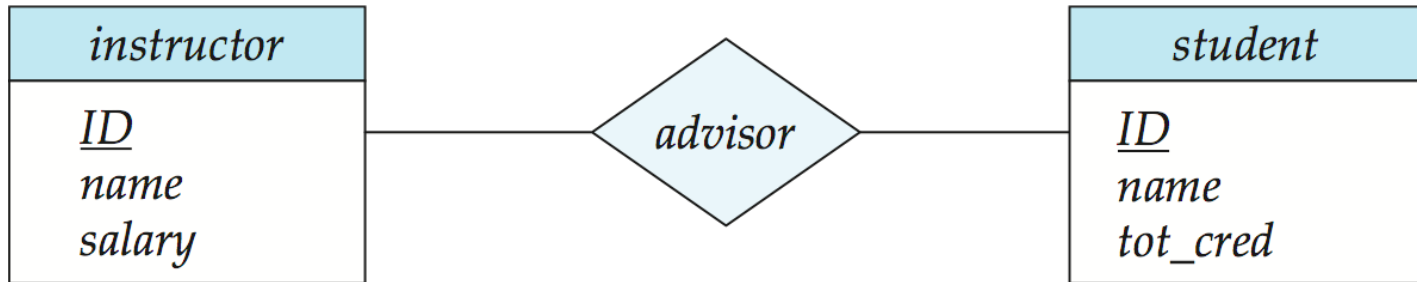
Many-to-One Relationships

- In a many-to-one relationship between an *instructor* and a *student*,
 - an instructor is associated with at most one student via *advisor*,
 - and a student is associated with several (including 0) instructors via *advisor*



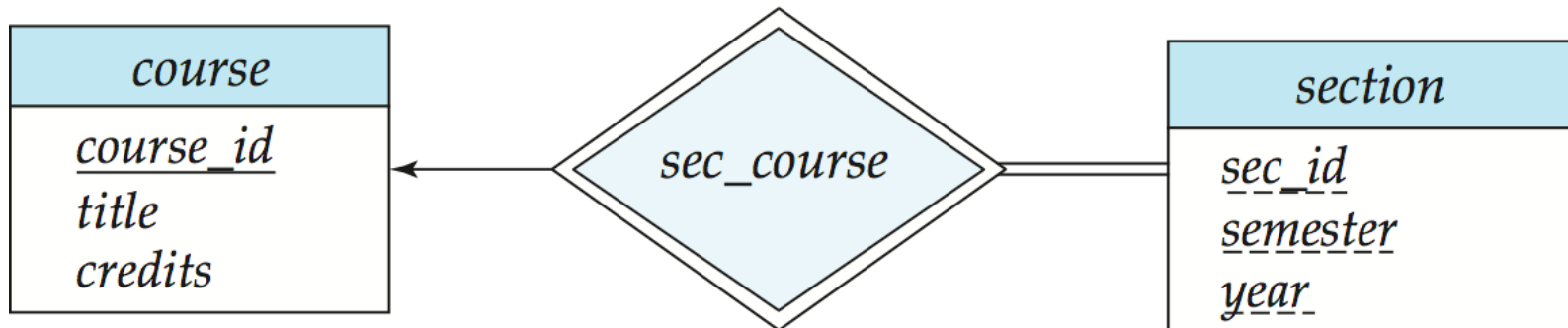
Many-to-Many Relationship

- An instructor is associated with several (possibly 0) students via *advisor*
- A student is associated with several (possibly 0) instructors via *advisor*



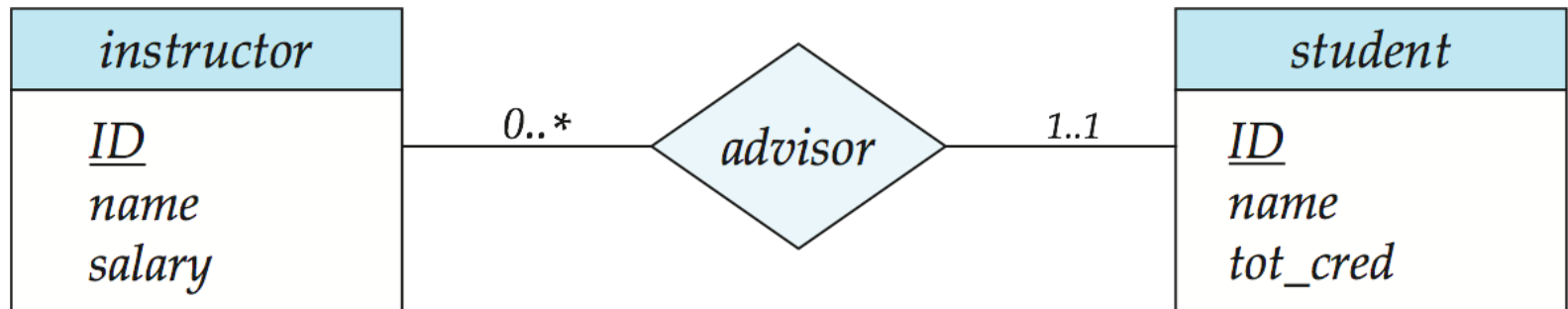
Participation of an Entity Set in a Relationship Set

- Total participation (indicated by double line): every entity in the entity set participates in at least one relationship in the relationship set
 - E.g., participation of *section* in *sec_course* is total
 - ▶ every *section* must have an associated course
- Partial participation: some entities may not participate in any relationship in the relationship set
 - Example: participation of *instructor* in *advisor* is partial

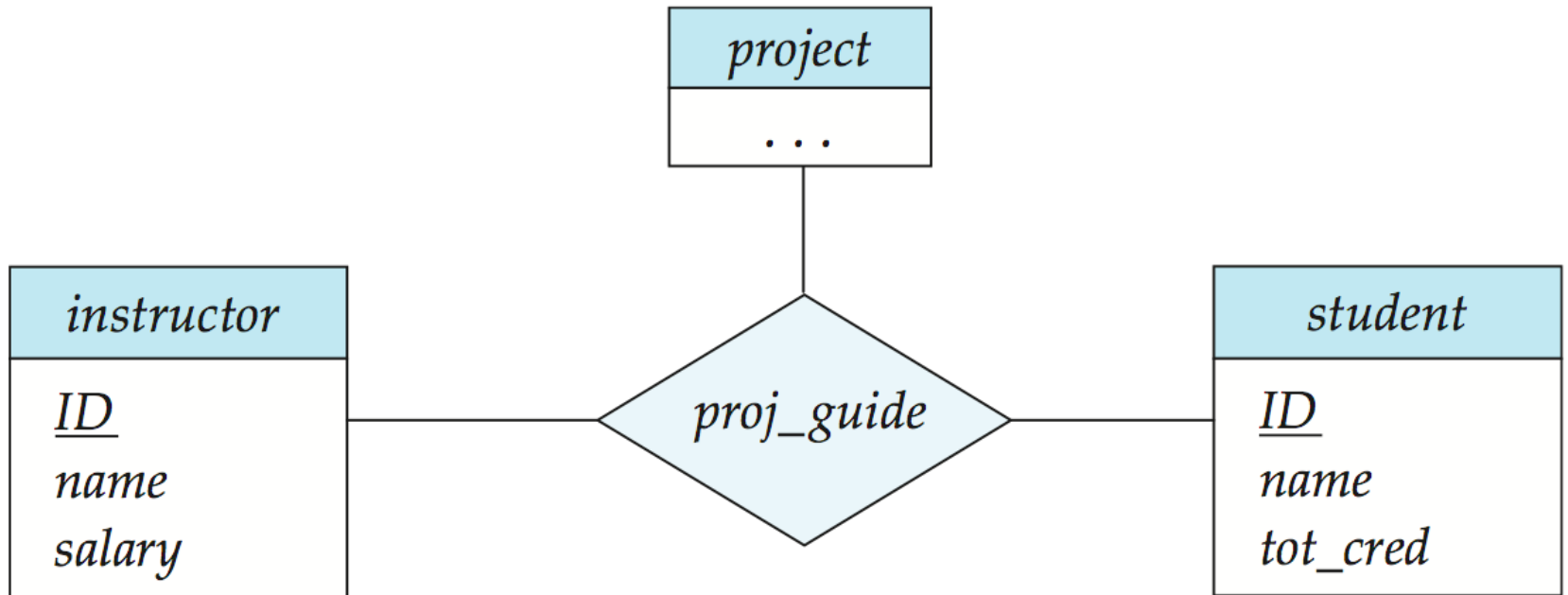


Alternative Notation for Cardinality Limits

- Cardinality limits can also express participation constraints



E-R Diagram with a Ternary Relationship



Cardinality Constraints on Ternary Relationship

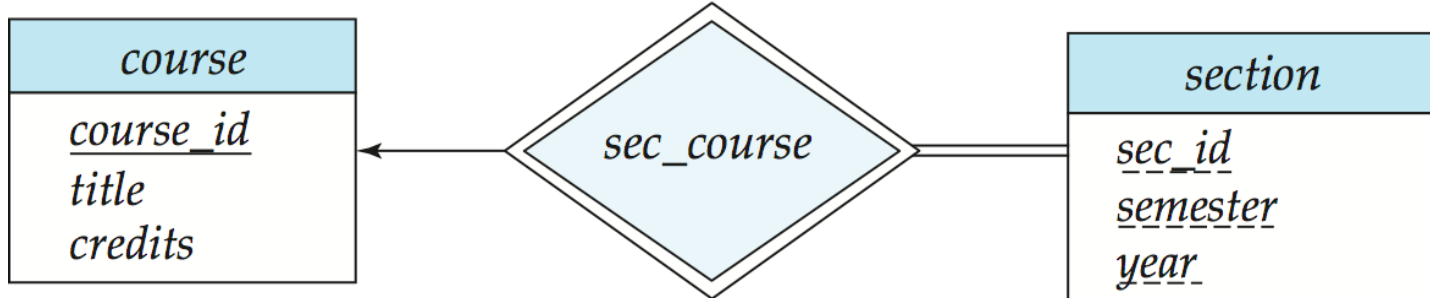
- We allow at most one arrow out of a ternary (or greater degree) relationship to indicate a cardinality constraint
- E.g., an arrow from *proj_guide* to *instructor* indicates each student has at most one guide for a project
- If there is more than one arrow, there are two ways of defining the meaning.
 - E.g., a ternary relationship R between A , B and C with arrows to B and C could mean
 1. each A entity is associated with a unique entity from B and C or
 2. each pair of entities from (A, B) is associated with a unique C entity, and each pair (A, C) is associated with a unique B
 - Each alternative has been used in different formalisms
 - To avoid confusion we outlaw more than one arrow

Weak Entity Sets

- An entity set that does not have a primary key is referred to as a **weak entity set**.
- The existence of a weak entity set depends on the existence of a **identifying entity set**
 - It must relate to the identifying entity set via a total, one-to-many relationship set from the identifying to the weak entity set
 - **Identifying relationship** depicted using a double diamond
- The **discriminator** (*or partial key*) of a weak entity set is the set of attributes that distinguishes among all the entities of a weak entity set.
- The primary key of a weak entity set is formed by the primary key of the strong entity set on which the weak entity set is existence dependent, plus the weak entity set's discriminator.

Weak Entity Sets (Cont.)

- We underline the discriminator of a weak entity set with a dashed line.
- We put the identifying relationship of a weak entity in a double diamond.
- Primary key for *section* – (*course_id*, *sec_id*, *semester*, *year*)



Weak Entity Sets (Cont.)

- Note: the primary key of the strong entity set is not explicitly stored with the weak entity set, since it is implicit in the identifying relationship.
- If *course_id* were explicitly stored, *section* could be made a strong entity, but then the relationship between *section* and *course* would be duplicated by an implicit relationship defined by the attribute *course_id* common to *course* and *section*

E-R Diagram for a University Enterprise

