Database Systems
Lecture09 – Database Design Using the E-R Model

SUNG KYUN KWAN UNIVERSITY

Beomseok Nam (남범석)

bnam@skku.edu

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 student, e,g., Williams
- Entities have **attributes**
  - Example: students have *names* and *phone numbers*
- An **entity set** is a set of entities of the same type that share the same properties.
  - Example: set of all students, departments, etc

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

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

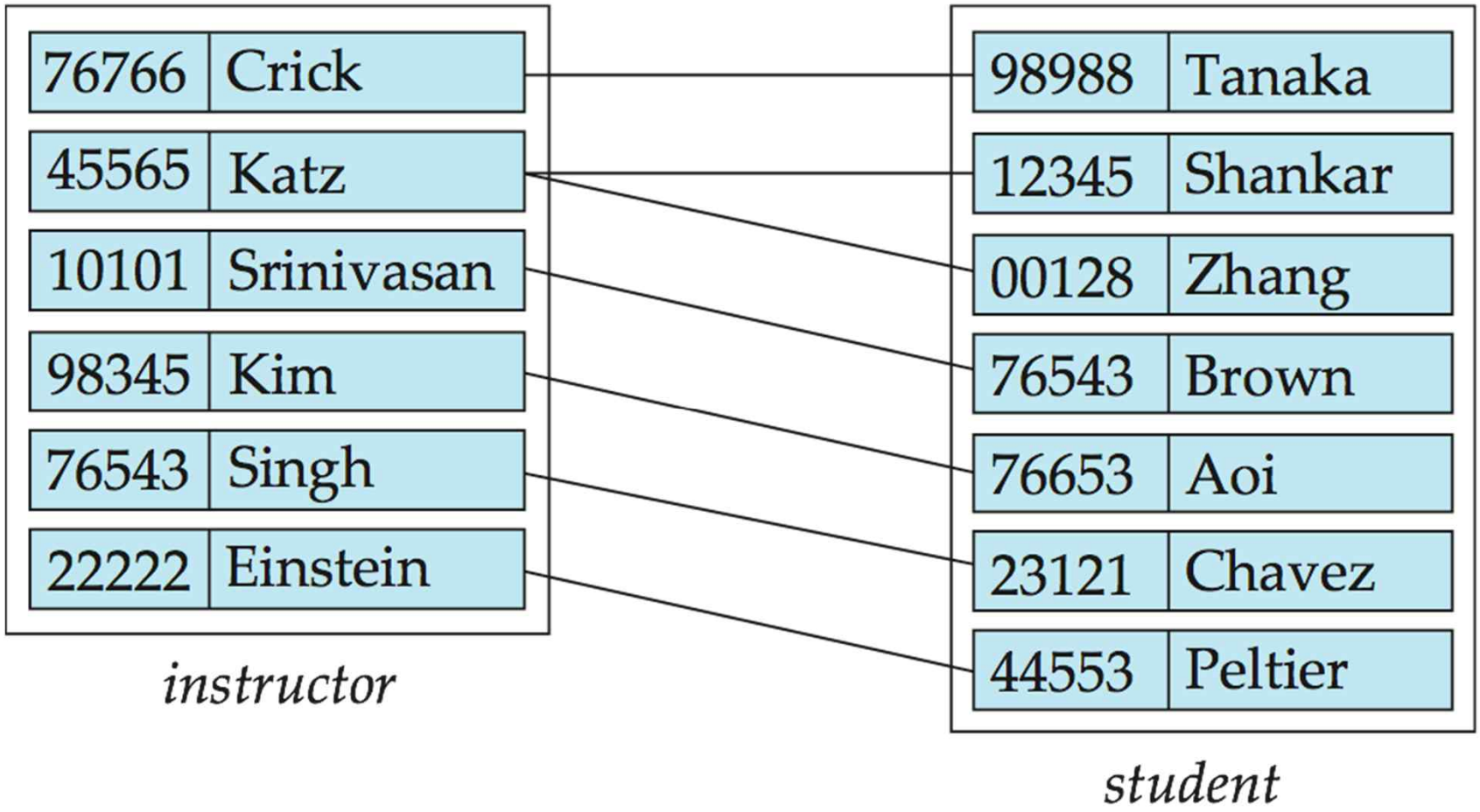
$$\{(e_1, e_2, \ldots e_n) \mid e_1 \in E_1, e_2 \in E_2, \ldots, e_n \in E_n\}$$

  where $(e_1, e_2, \ldots, e_n)$ is a relationship

  - Example:

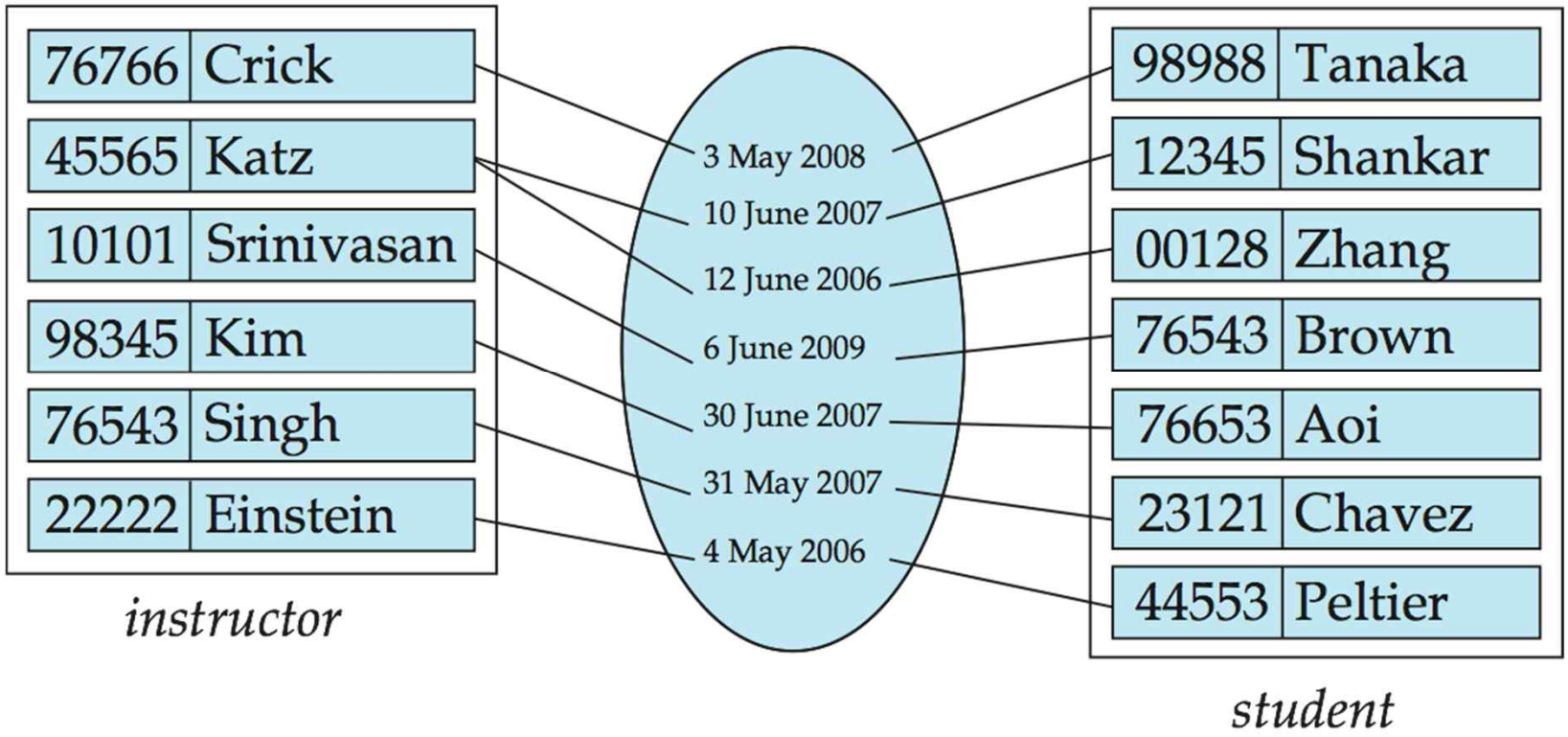
$$(44553,22222) \in advisor$$

Relationship Set *advisor*



Relationship Sets (Cont.)

- An **attribute** can also be property of a relationship set.
  - For instance, the *advisor* relationship set between *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 relationships are binary.
  - Relationships between more than two entity sets are rare.

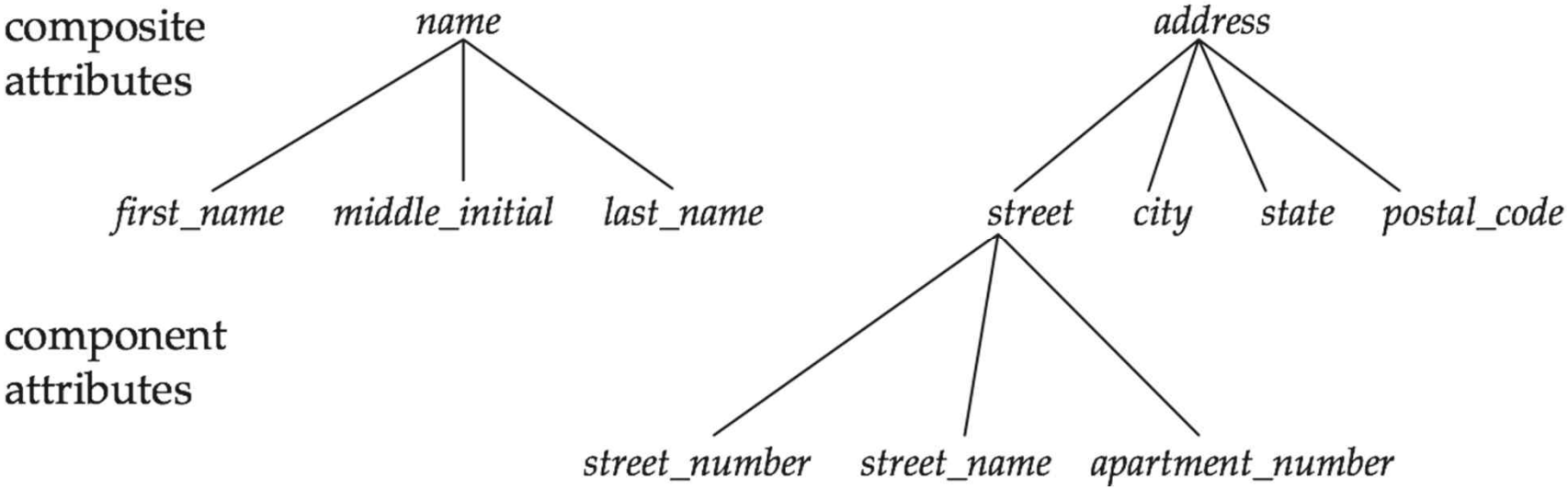
    - Example: *students* work on research *projects* under the guidance of an *instructor*.
    - relationship *proj_guide* is a ternary relationship between *instructor, student,* and *project*

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*
      - *a person can have more than one phone number.*
  - **Derived** attributes
    - Can be computed from other attributes
    - Example: age, given date_of_birth

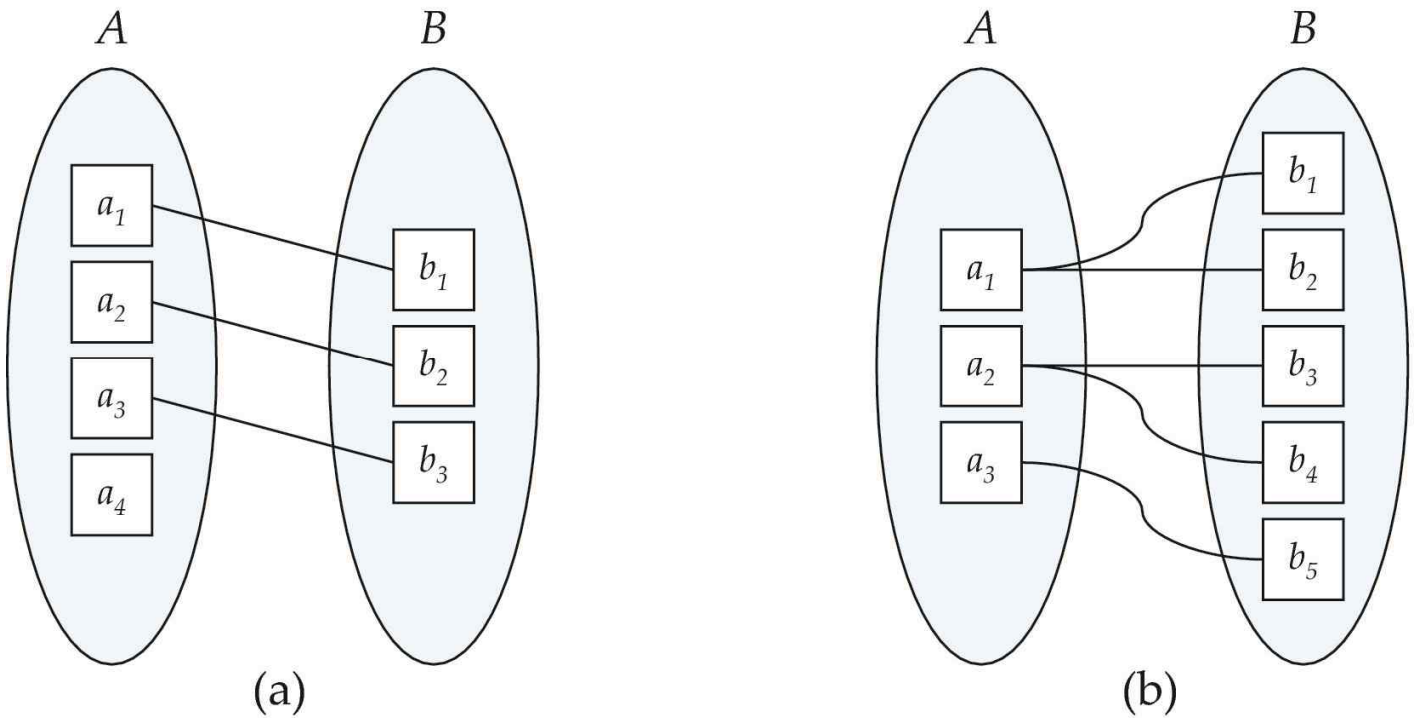
Composite Attributes



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

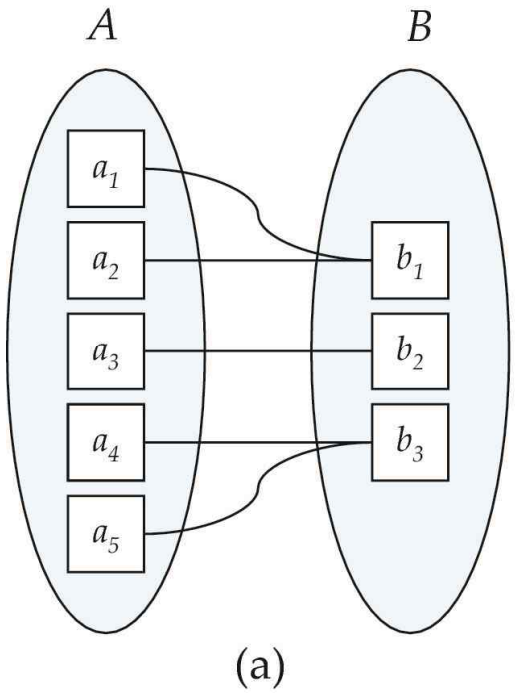


One to one

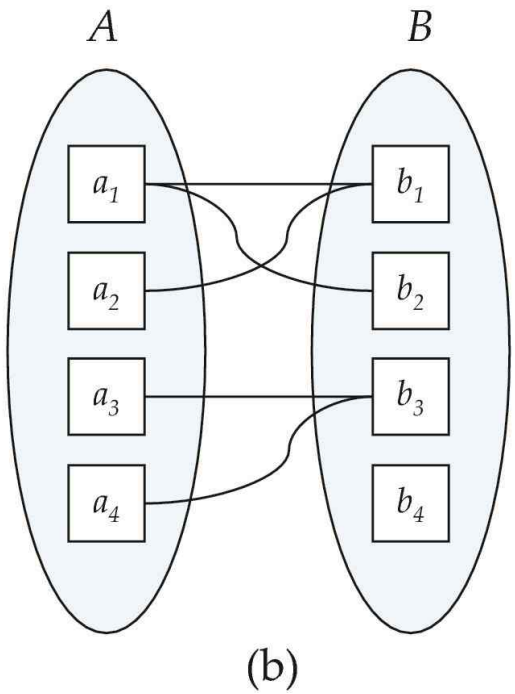
One to many

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

Mapping Cardinalities



Many to one

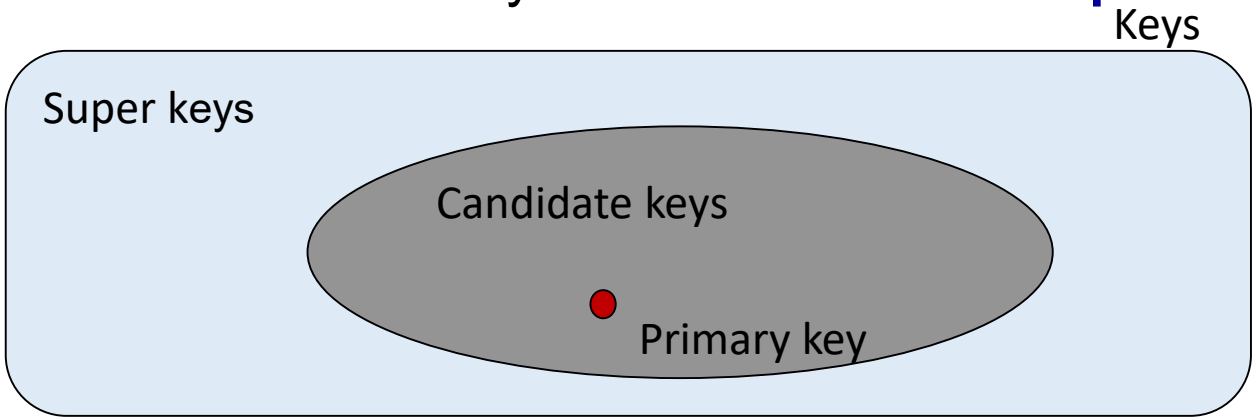


Many to many

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

Keys

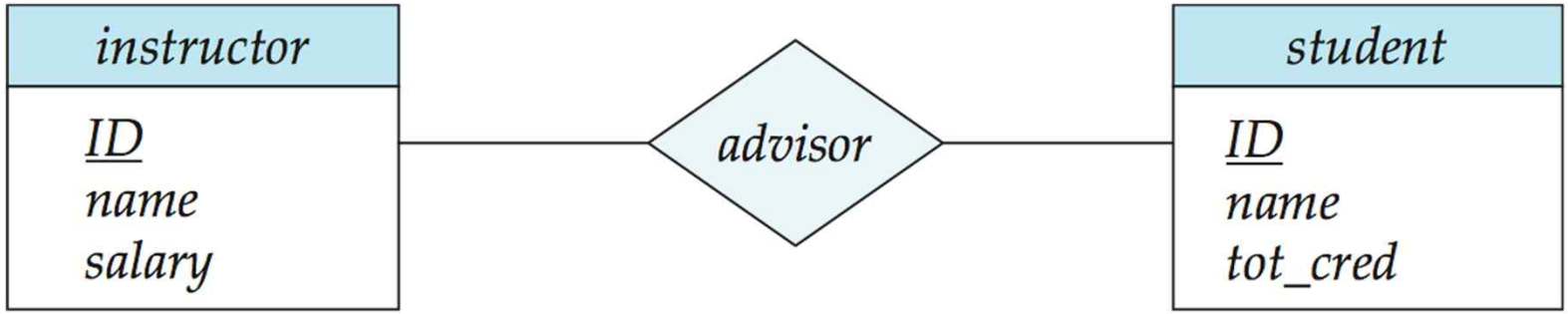
- **Key** (an attribute or composite attrs) is a unique identifier of a record.
  - **Super key** is a set of attributes that uniquely determines each entity.
    - *(ID, name)* is a super key of *instructor*
  - A **candidate key** is a minimal super key
    - *ID* is a candidate key of *instructor*
    - *course_id* is a candidate key of *course*
  - Several candidate keys may exist
  - One of the candidate keys is selected to be the **primary key**.



Keys for Relationship Sets

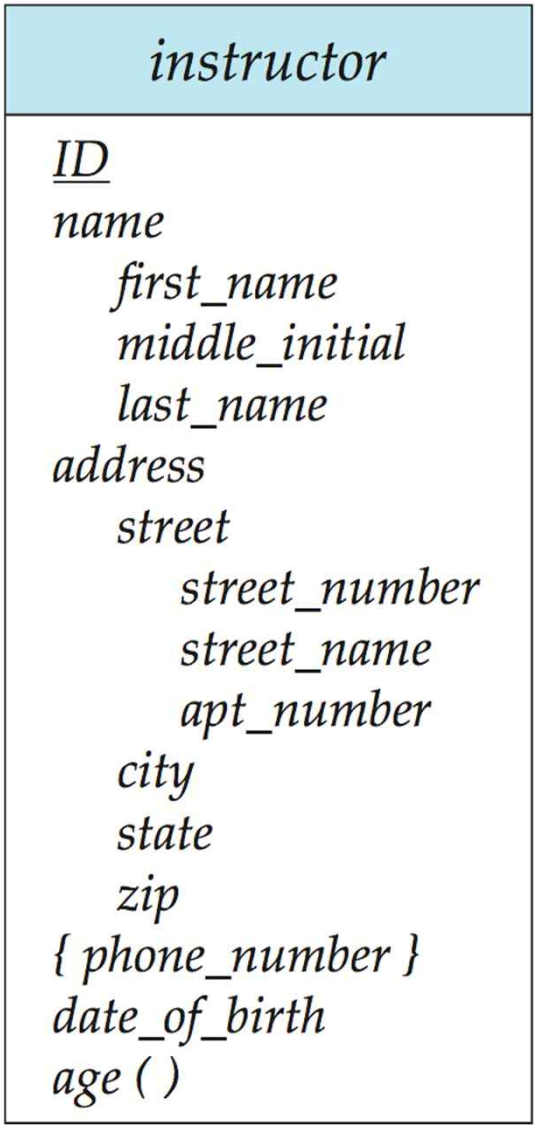
- The combination of primary keys of the participating entity sets forms a super key of a relationship set.
  - E.g.)
    s_id is the primary key of student
    ID is the primary key of instructor
    → (s_id, i_id) is the super key of advisor

E-R Diagrams



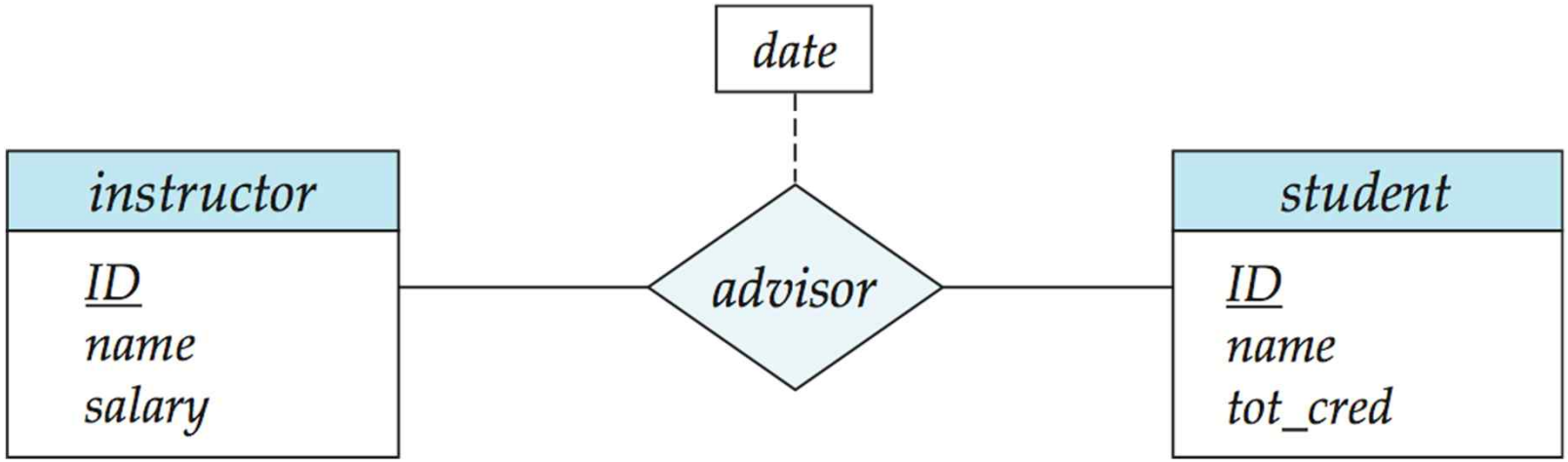
- Rectangles represent entity sets.
- Diamonds represent relationship sets.
- Attributes listed inside entity rectangle
- Underline indicates primary key attributes

Entity With Composite, Multivalued, and Derived Attributes



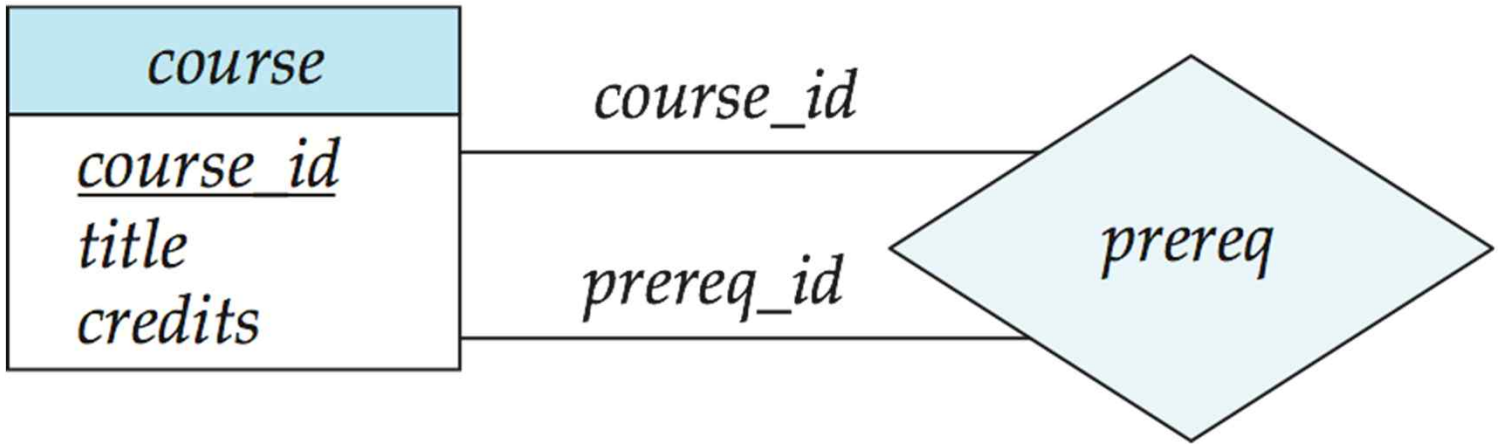
- Composite attributes are flattened out by creating a separate attribute for each component attribute
- Ignoring multivalued attributes, extended instructor schema is
  - *instructor(ID, first_name, middle_initial, last_name, street_number, street_name, apt_number, city, state, zip_code, date_of_birth)*

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 line types
  - directed line ($\rightarrow$), signifying “one”
  - undirected line (—), signifying “many,”

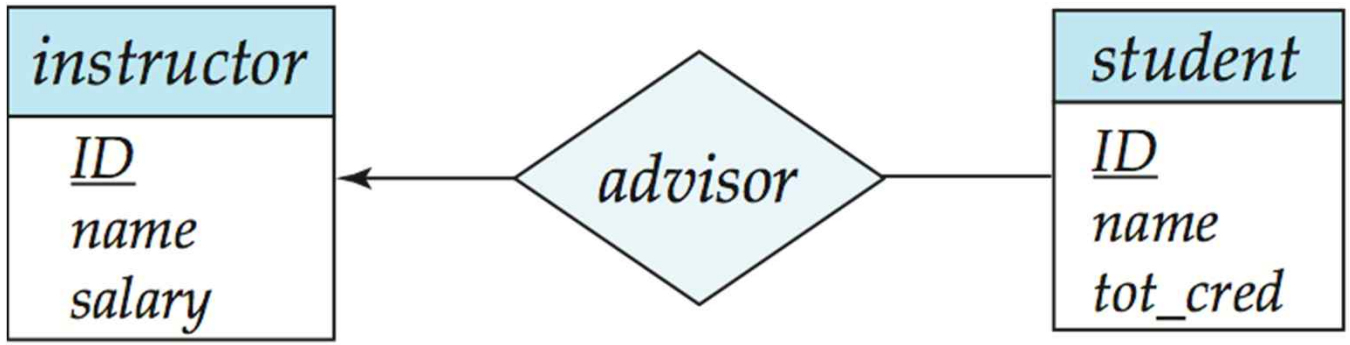
- One-to-one relationship:
  - A student is associated with at most one *instructor* via the relationship *advisor*
  - A *student* is associated with at most one *department* via *stud_dept*

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,

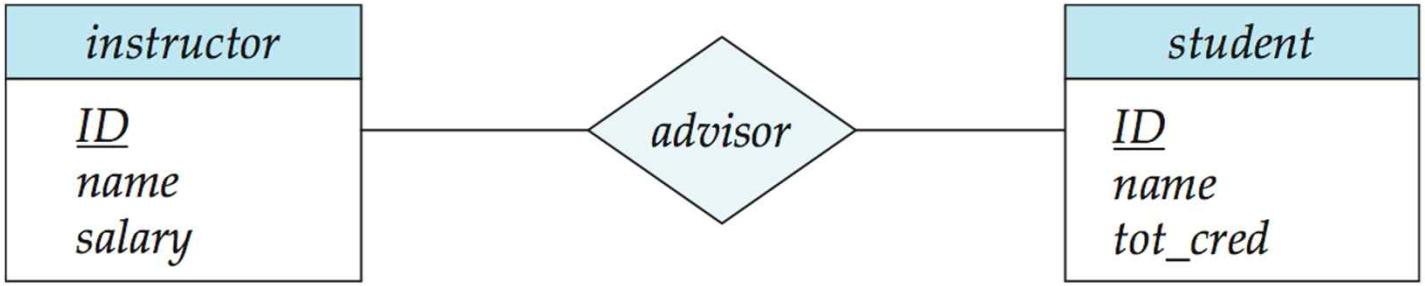


Many-to-One Relationships

- 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*

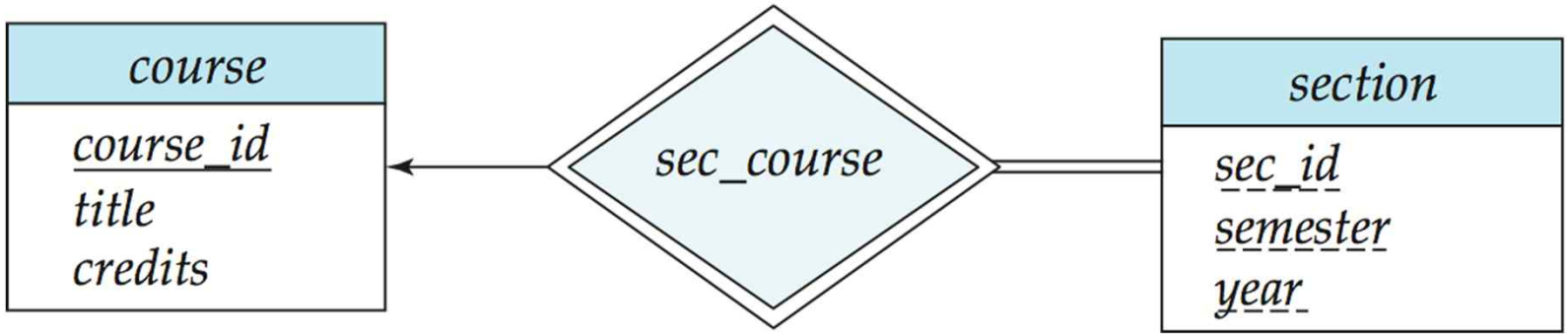
Many-to-Many Relationship

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



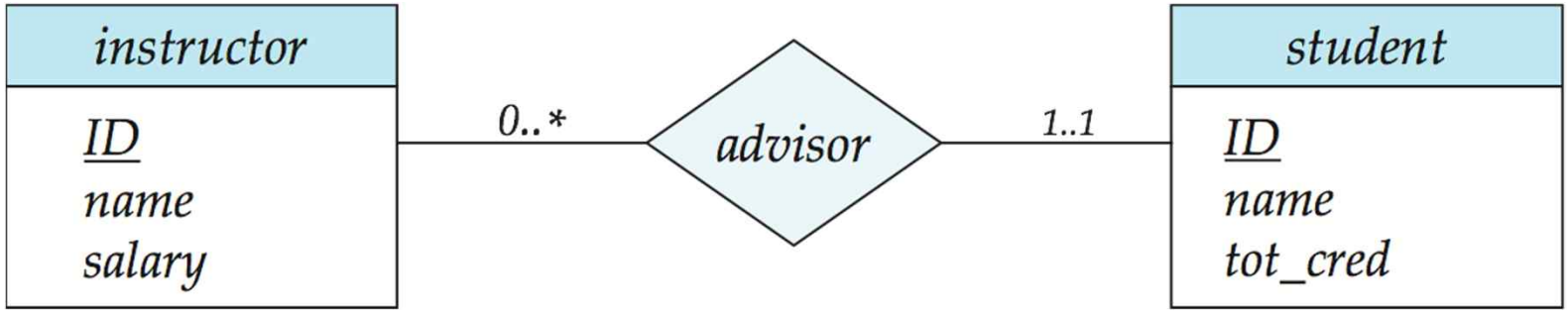
Participation of an Entity Set in a Relationship Set

- **Total participation** (indicated by double line):
  - every entity in the entity set participates in at least one relationship
  - E.g., participation of section in *sec_course* is total
    - every section must have an associated course
  - Partial participation: The opposite of total participation

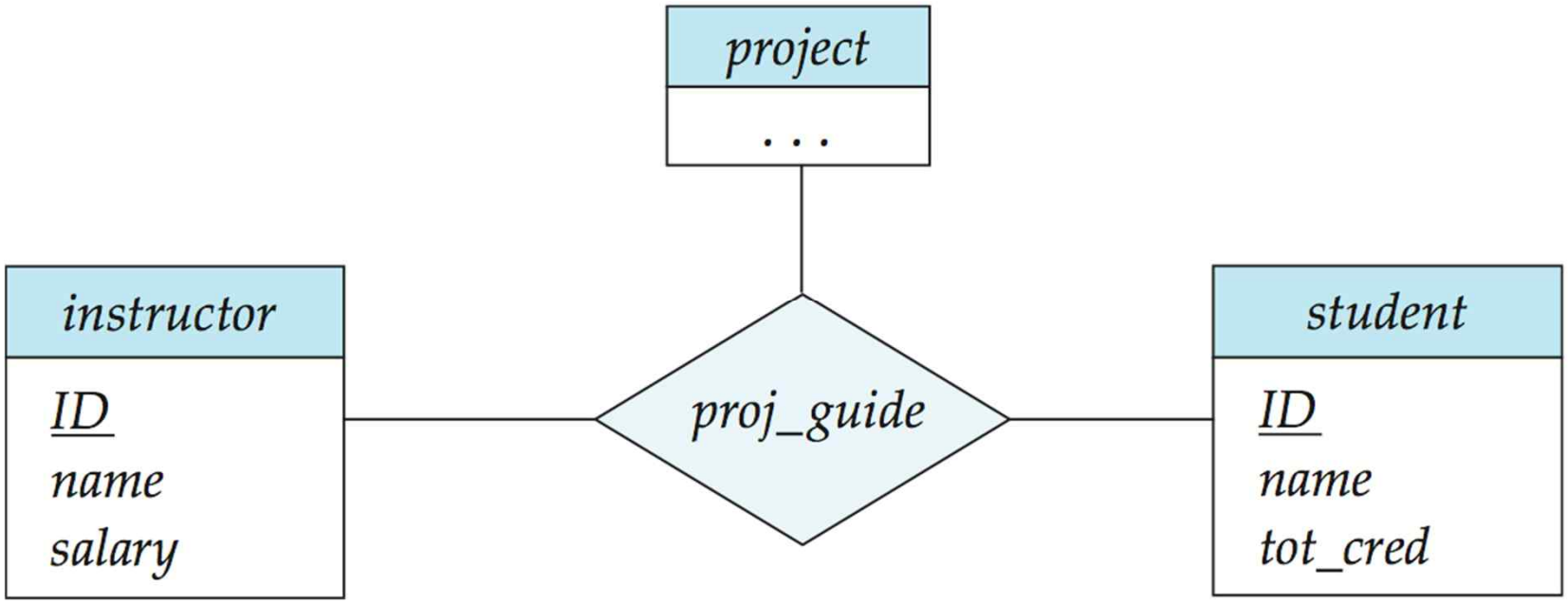


Alternative Notation for Cardinality Limits

- Cardinality limits can 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 confusing 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

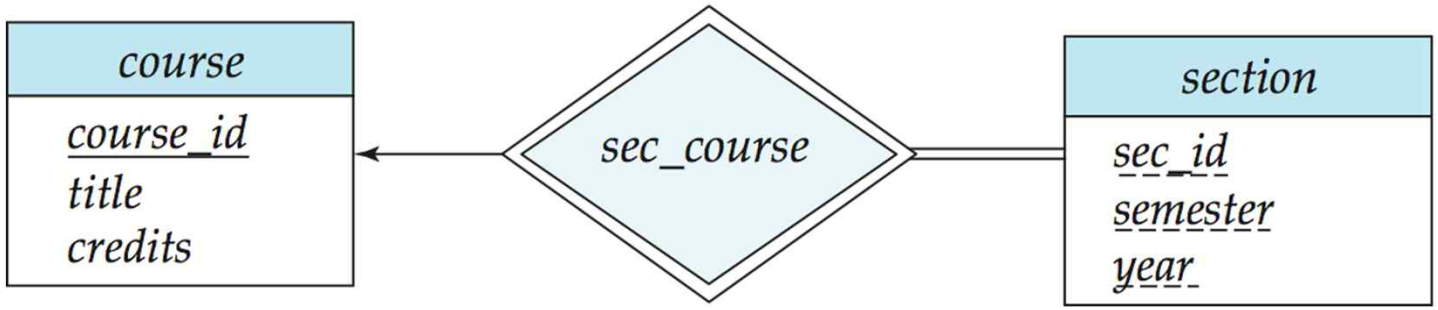
    2. each pair of entities from (*A, B*) is associated with a unique *C* entity, and each pair (*A, C*) is associated with a unique *B*
  - Each alternative has been used in different formalisms
  - To avoid confusion ***we outlaw more than one arrow***

Weak Entity Sets

- An entity set that does not have a primary key is a **weak entity set**.
- Weak entity set depends on **identifying entity set**
  - It relates to the identifying entity set via a total, one-to-many relationship 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 an entity of a weak entity set.
- The primary key of a weak entity set is formed by the primary key of the identifying entity set 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