Universiteit Antwerpen

Introduction to Databases

Lecture 1:Entity Relationship Modelling

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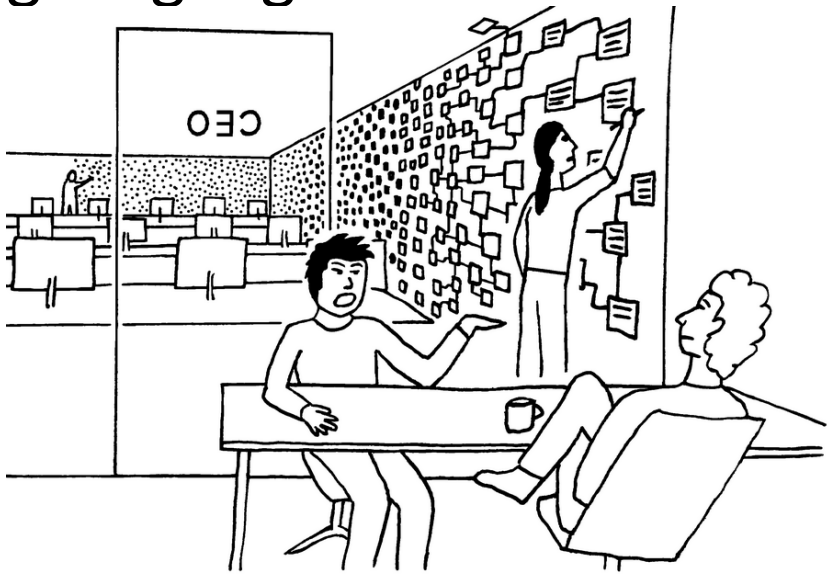
Today's lecture

- Objective:

  Based on a **requirements analysis**, design a conceptual model using the **Entity-Relationship** modelling language

- Content:
  - Entities
  - Relations
  - Attributes and primary keys
  - Constraints



ER modelling

- Is the **first step** towards a building a (relational) database for a customer

- Aims at **putting structure** to the chaos and **identify** clearly what parts of the data needs to **modelled**, what the important **features** are, and how everyting is c**onnected**.

- After **ER model** is in place, database designer starts converting this into a “proper” database.

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

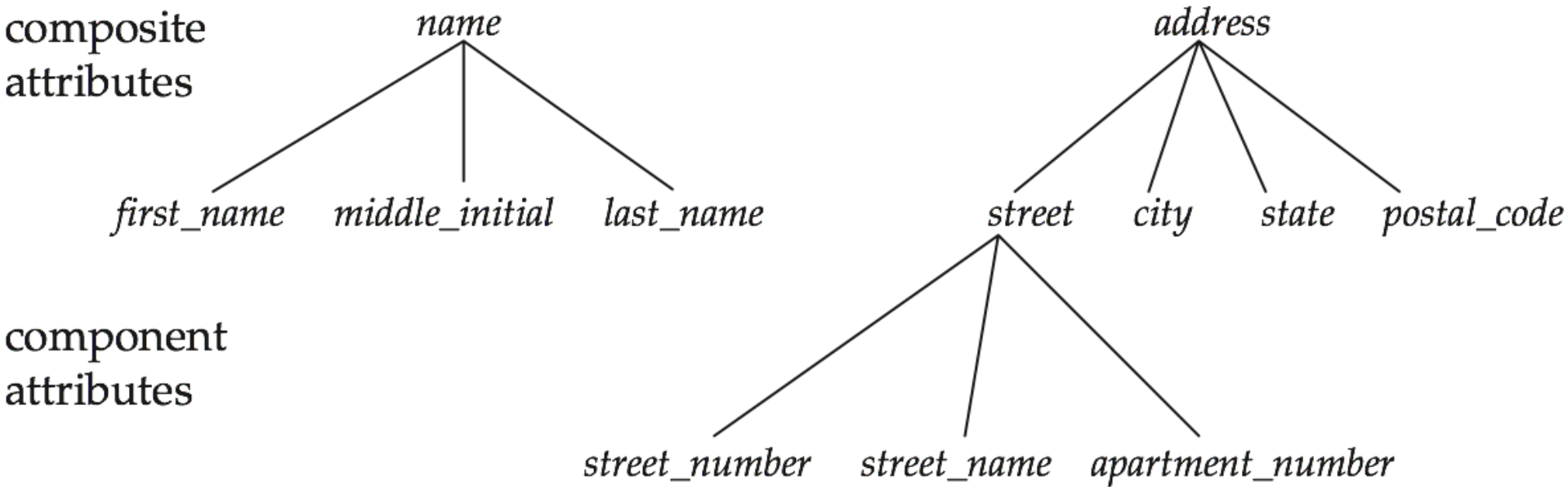
student

Entities

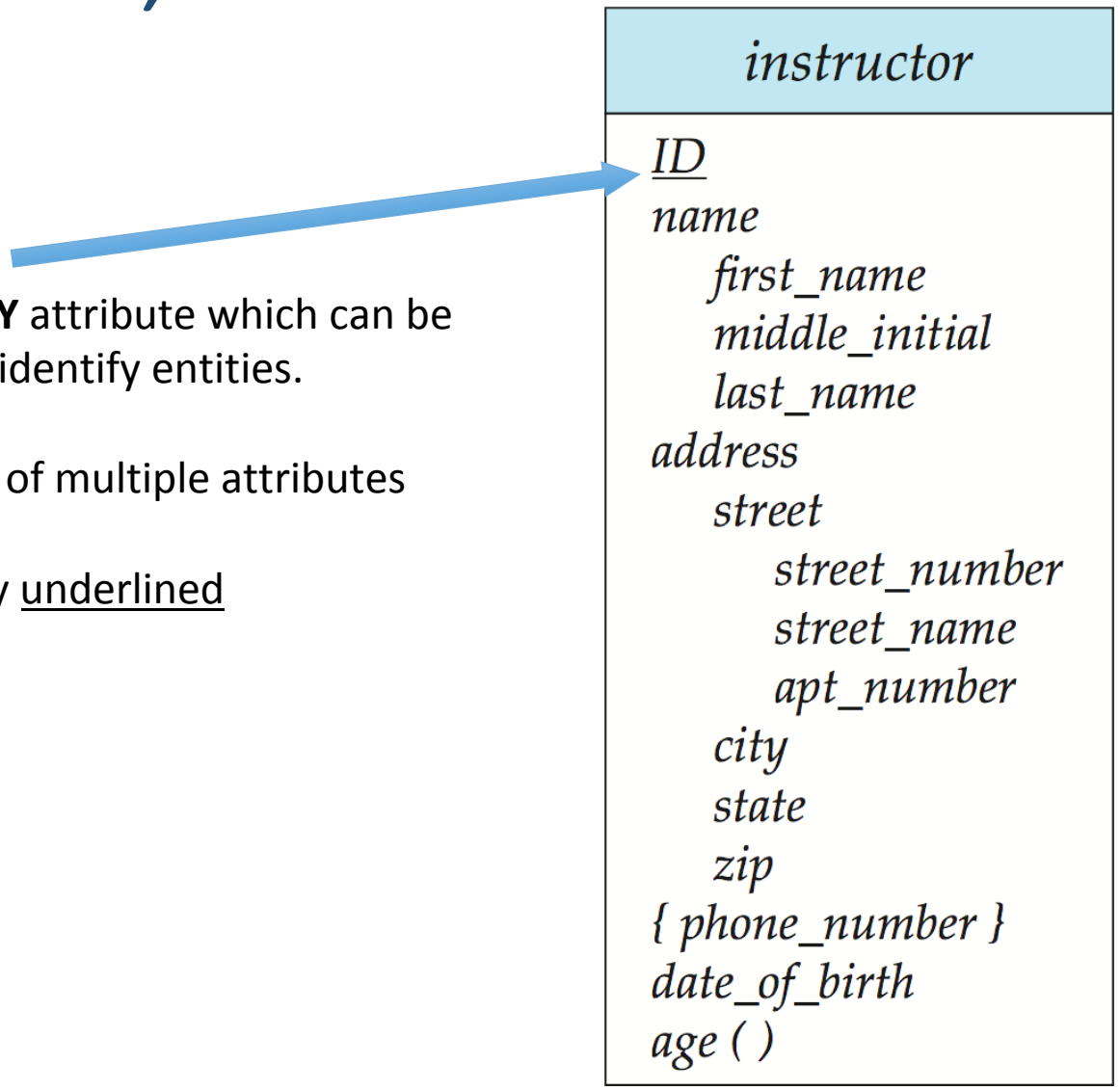
- An entity is represented by a set of attributes, that is descriptive properties possessed by all members of an entity set.
  - Example:

    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 multi-valued attributes
    - Example: multivalued attribute: phone_numbers
  - Derived attributes
    - Can be computed from other attributes
  - Example: age (given date_of_birth)

Composite Attributes



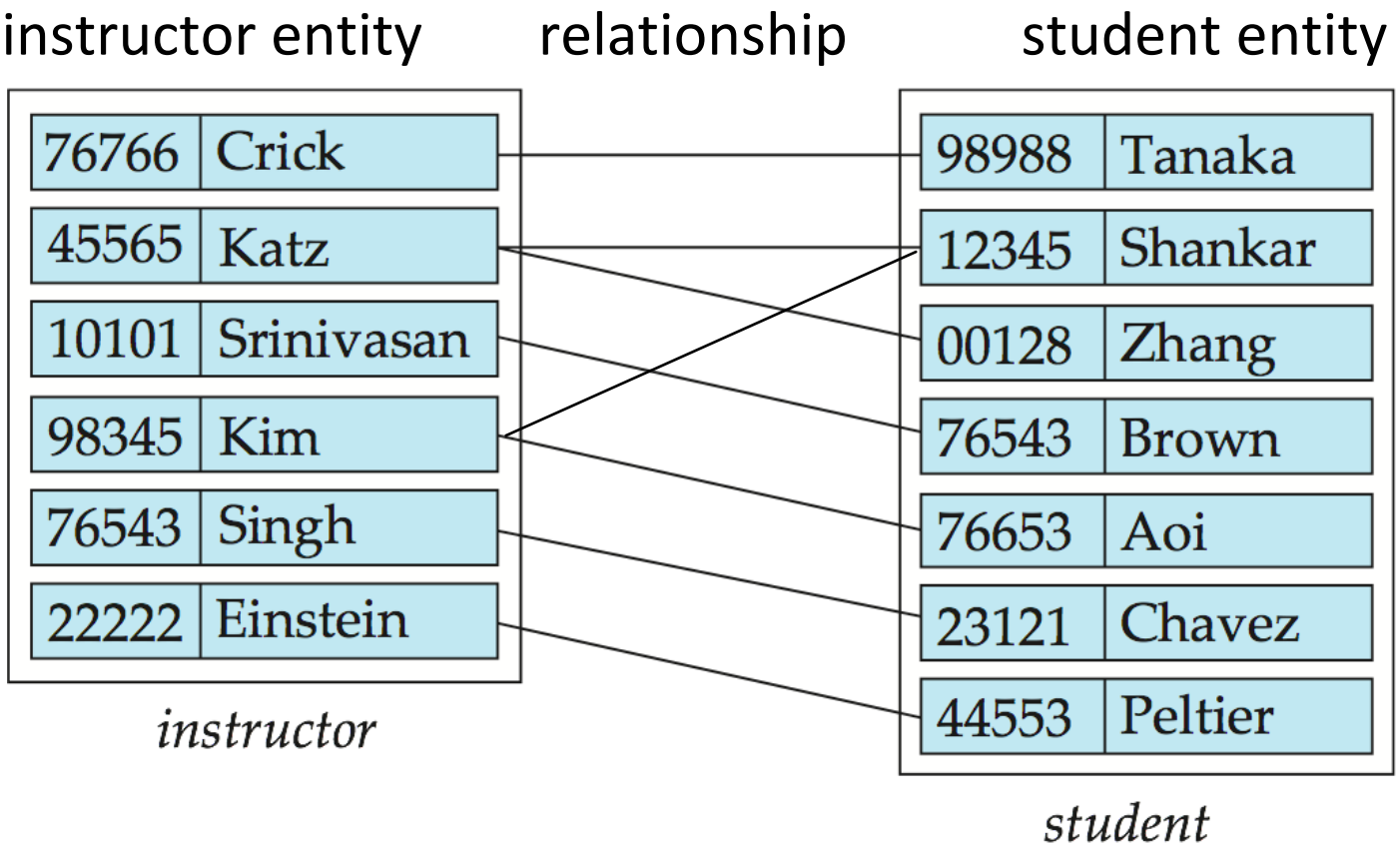
Example ER Diagram With Composite, Multivalued, and Derived Attributes



- ID is a special **KEY** attribute which can be used to uniquely identify entities.
- A key can consist of multiple attributes
- Keys are typically underlined

Relationship Sets

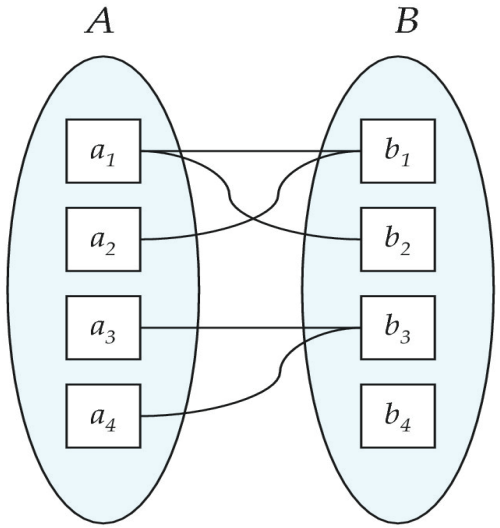
- A relationship is an association among several entities



Relationship Sets

- Relationship describes a subset of the Cartesian product of the entities involved

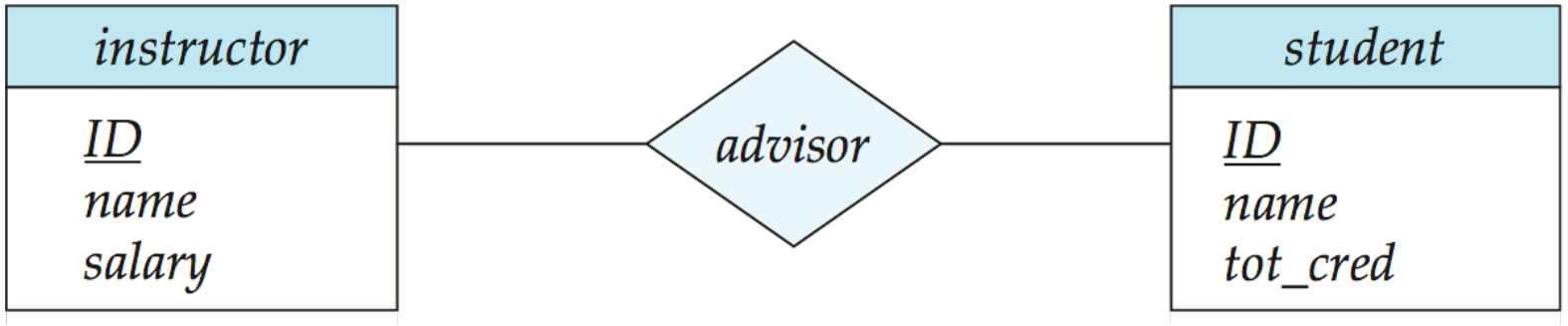
A={a1, a2, a3, a4},
B={b1, b2, b3, b4}



- Relationship between keys of entities involved.

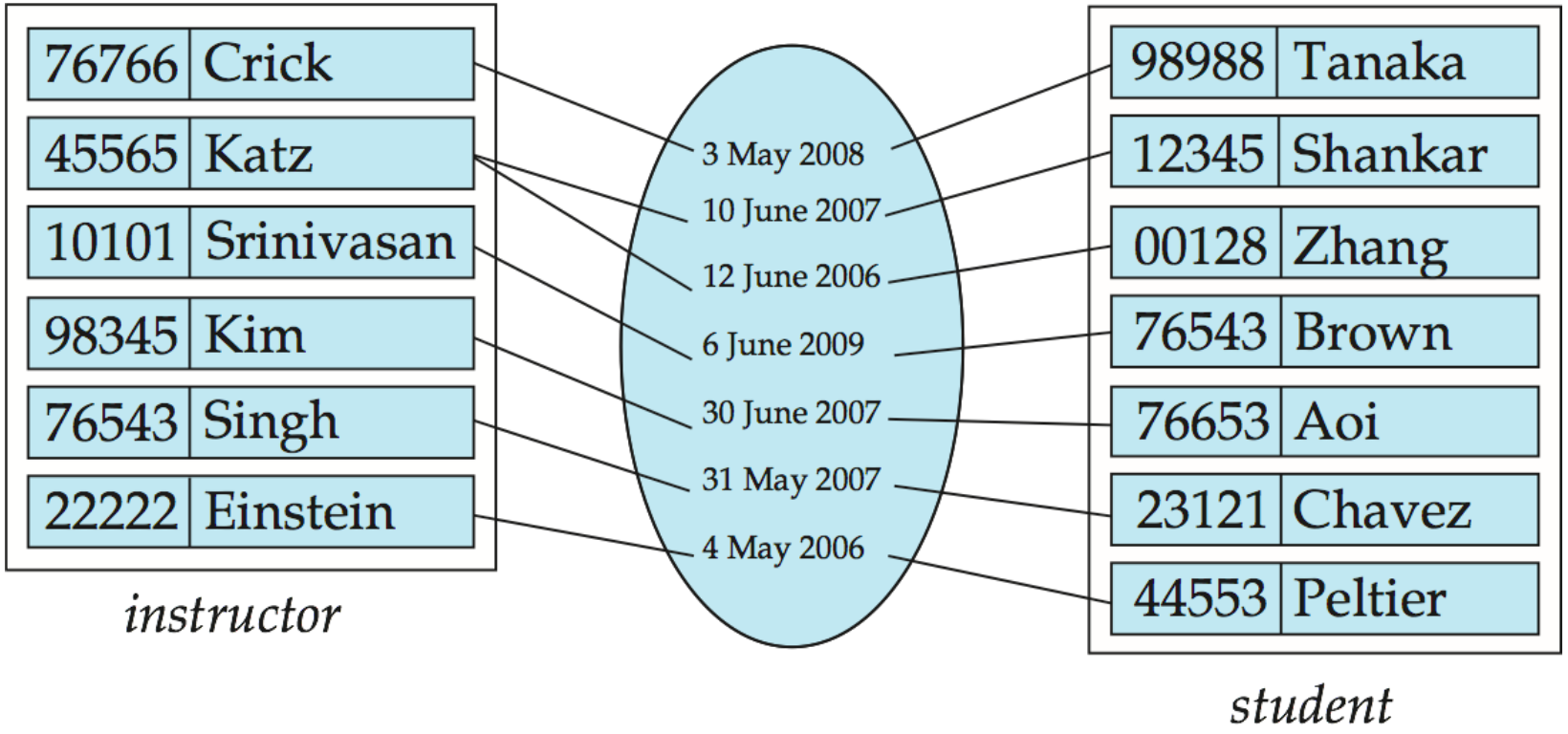
Entity-Relationship Diagrams

- Rectangles represent entity sets.
- Diamonds represent relationship sets.
- Lines link entity sets to relationship sets.
- Attributes listed inside entity rectangle.
- Underline indicates primary key attributes (unique identifiers)

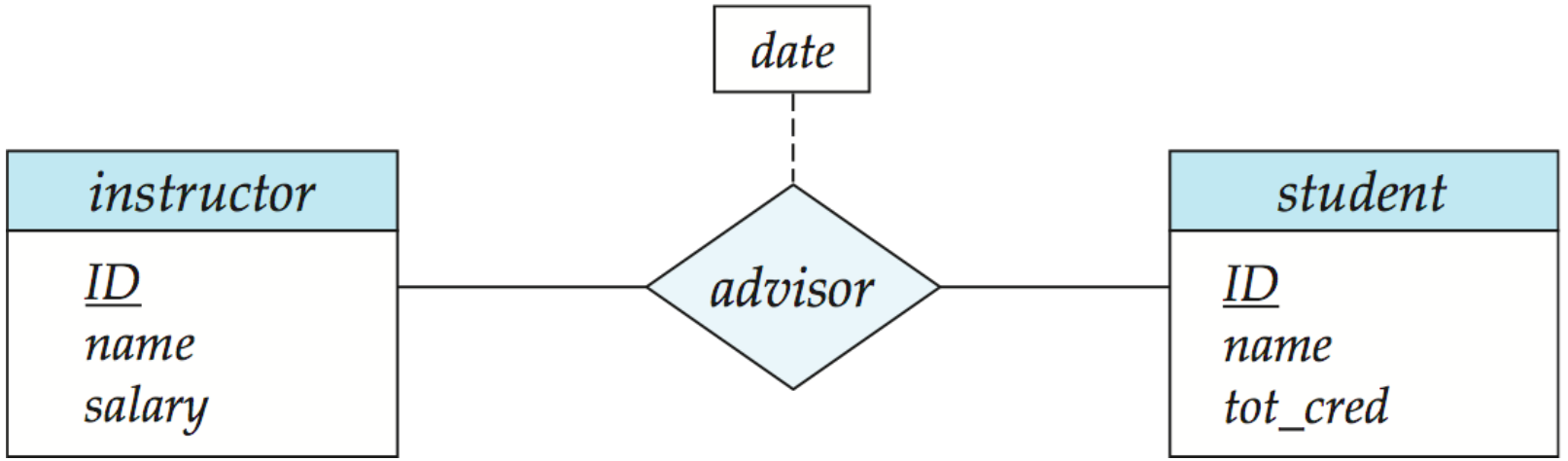


Relationship Sets

- An attribute can also be property of a relationship set.
- For instance, the advisor relationship set between entity sets instructor and student may have an attribute date



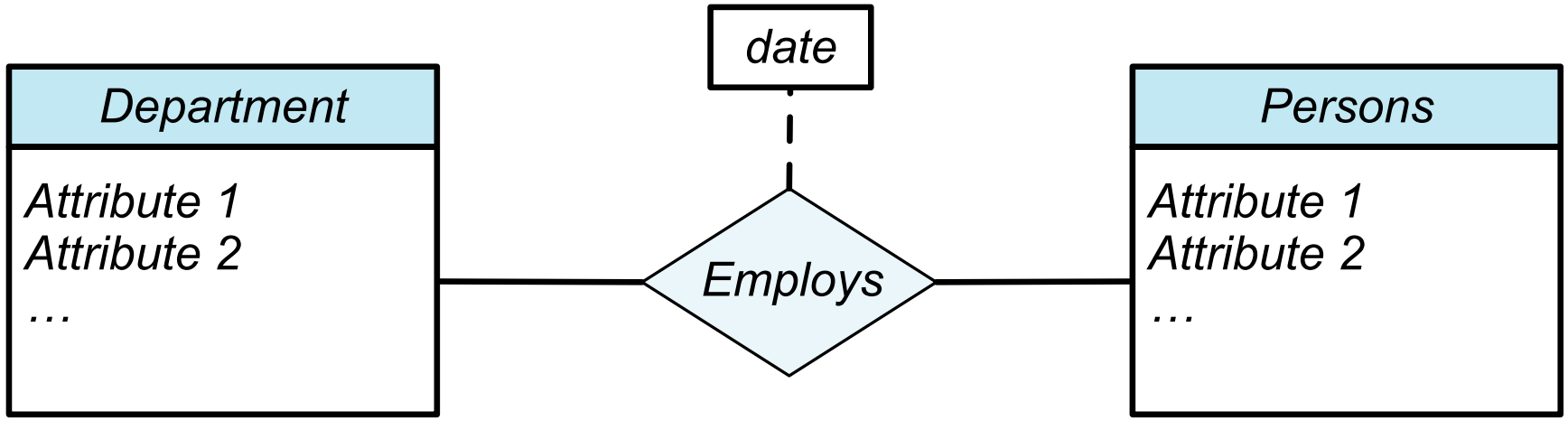
Relationship with Attribute



- Every instructor-student pair that is in an “advisor” relationship has a value for the attribute “date.”

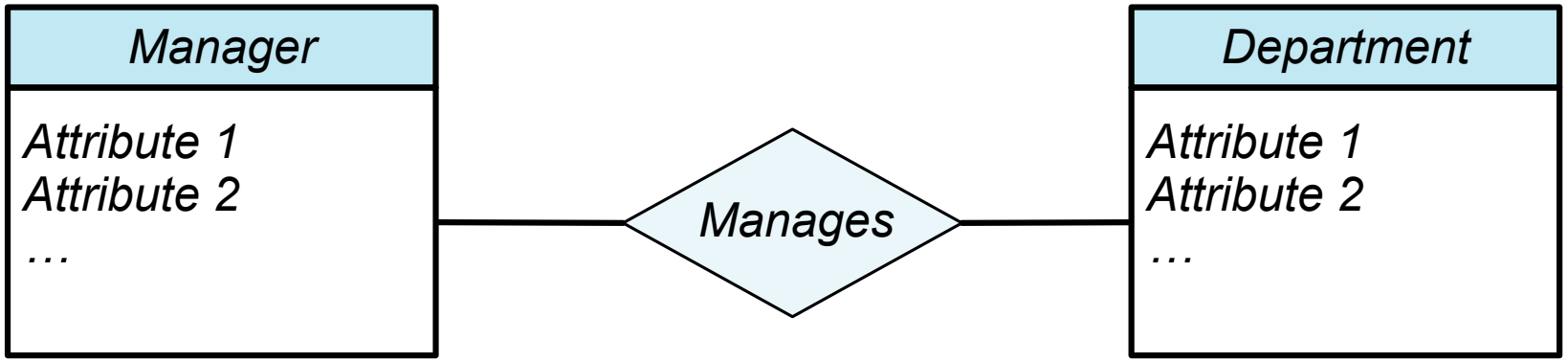
Question

- Identify the entities and relationships in the following examples:
  - A department employs many persons. A person is employed by~~, at most,~~ one department.



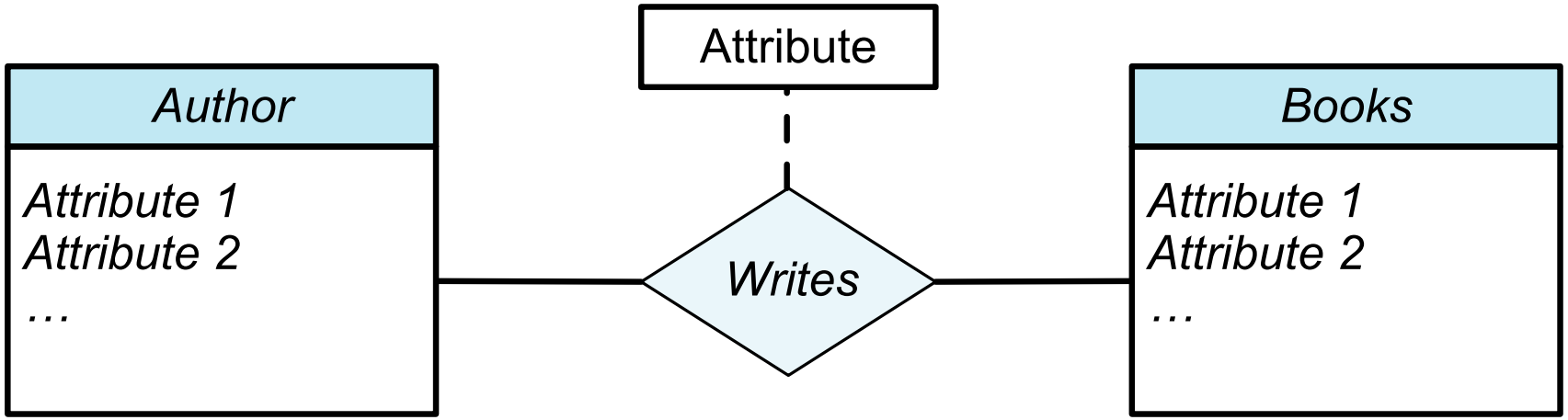
Question

- Identify the entities and relationships in the following examples:
  - A manager manages~~, at most, one~~ department. A department is managed by, ~~at most, one~~ manager.



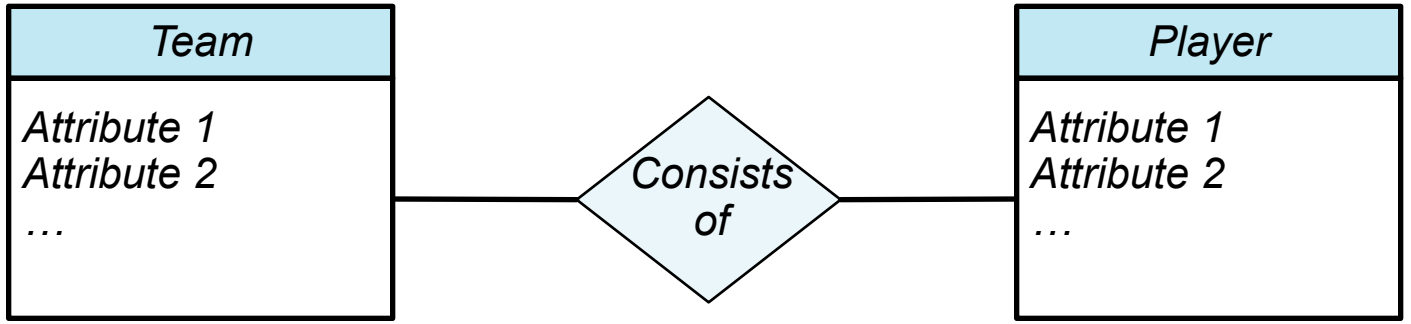
Question

- Identify the entities and relationships in the following examples:
  - An author may write many books. A book may be written by many authors.



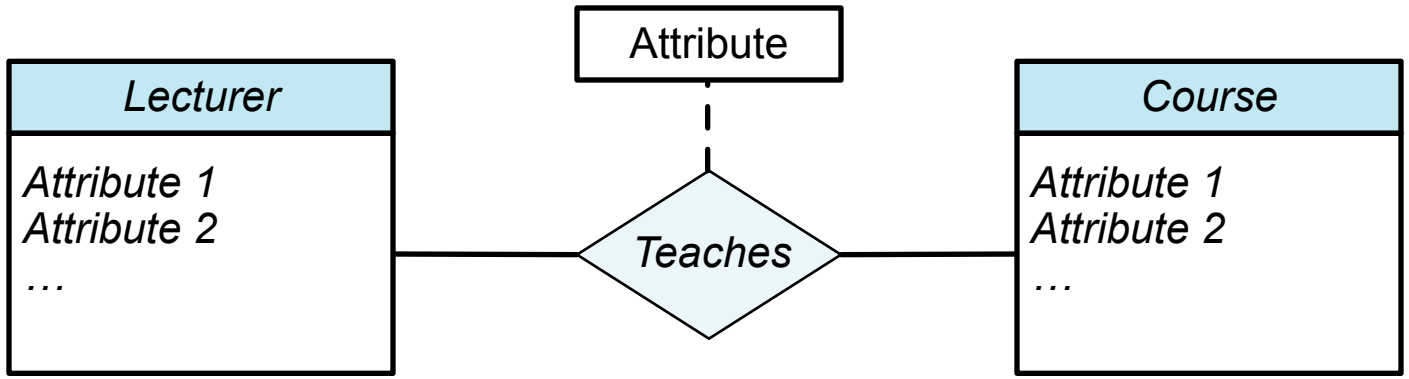
Question

- Identify the entities and relationships in the following examples:
  - A team consists of many players. A player plays for ~~only~~ one team.



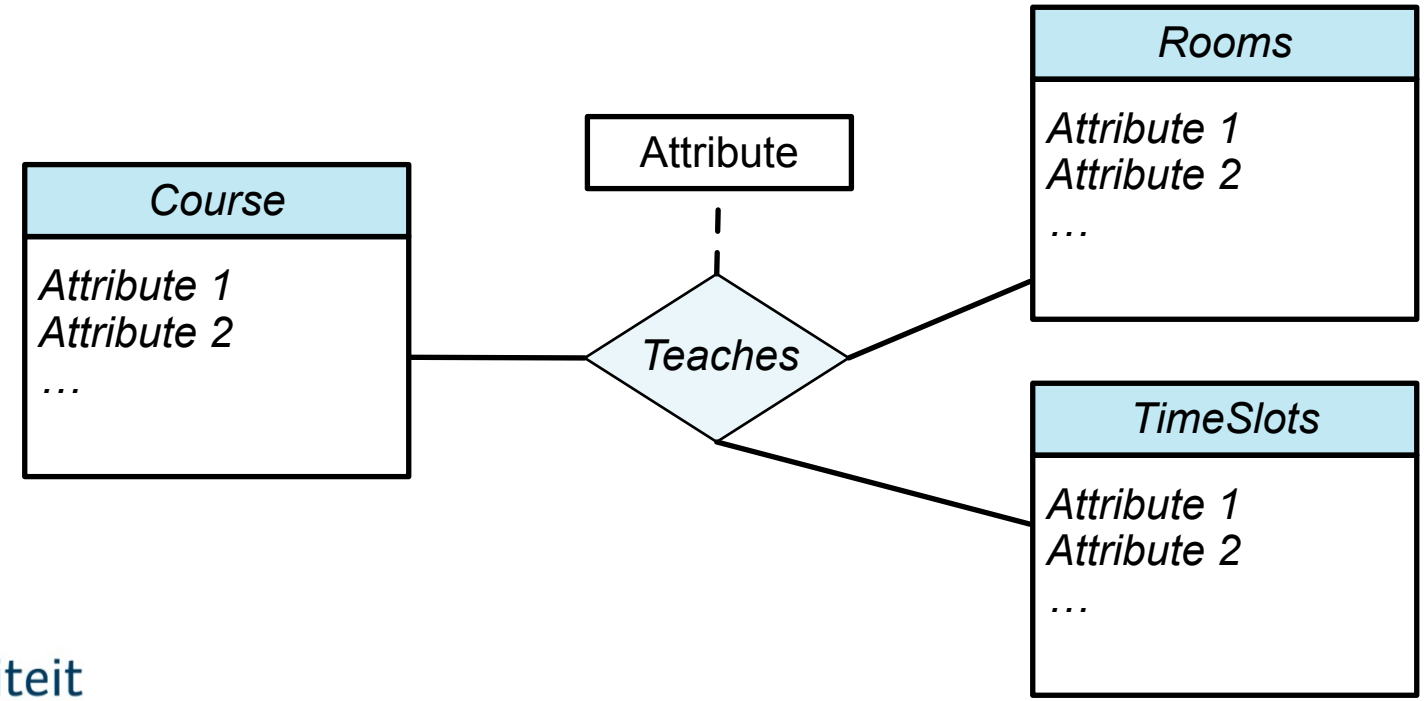
Question

- Identify the entities and relationships in the following examples:
  - A lecturer teaches, a~~t most, one~~ course. A course is taught by ~~exactly one~~ lecturers.



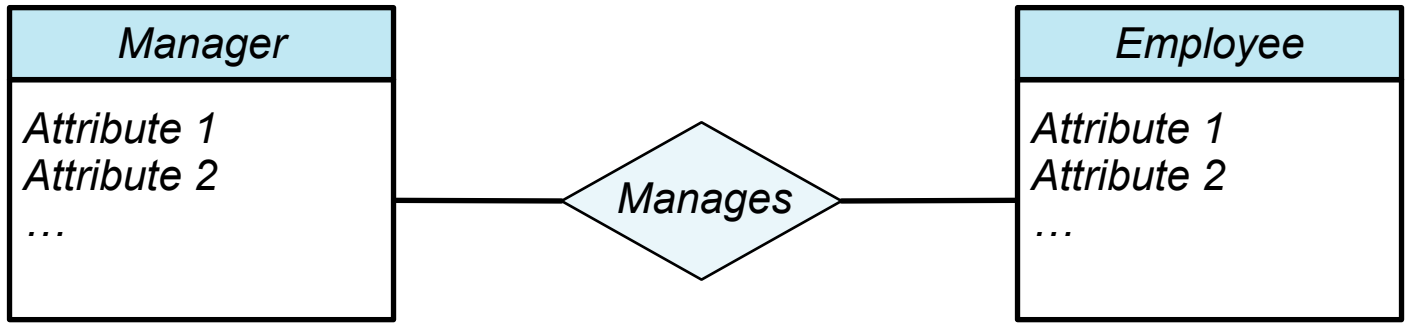
Relations between more than 2 entities

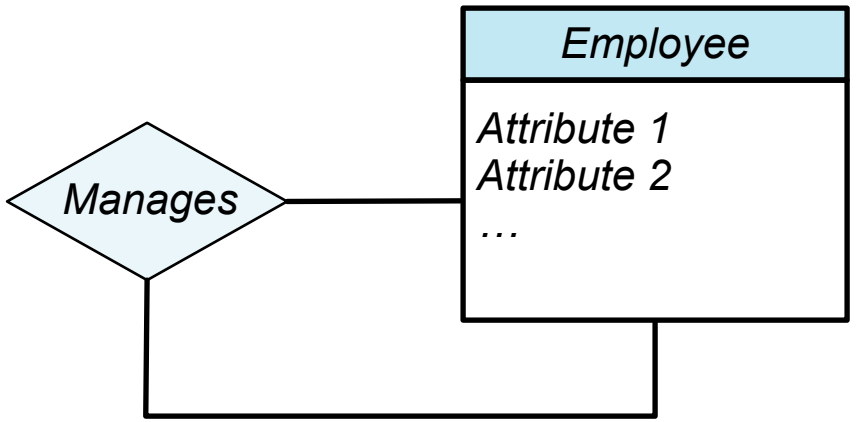
- We can have relations between as many entity sets as we want
  - However, very uncommon to have more than 3
- For instance: for a course different rooms are booked at different timeslots



Relations between an entity and itself

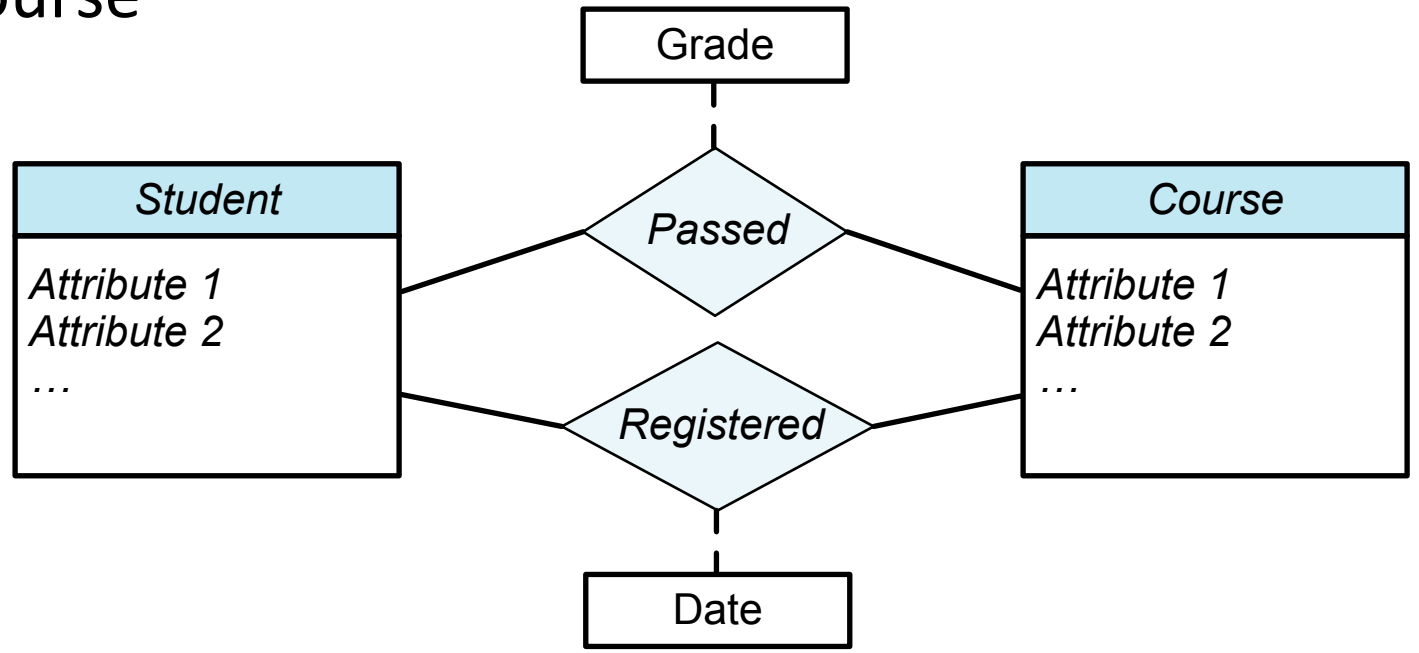
- Relations do not necessarily have to be between different entities
- Example: a manager is an employee managing another employee





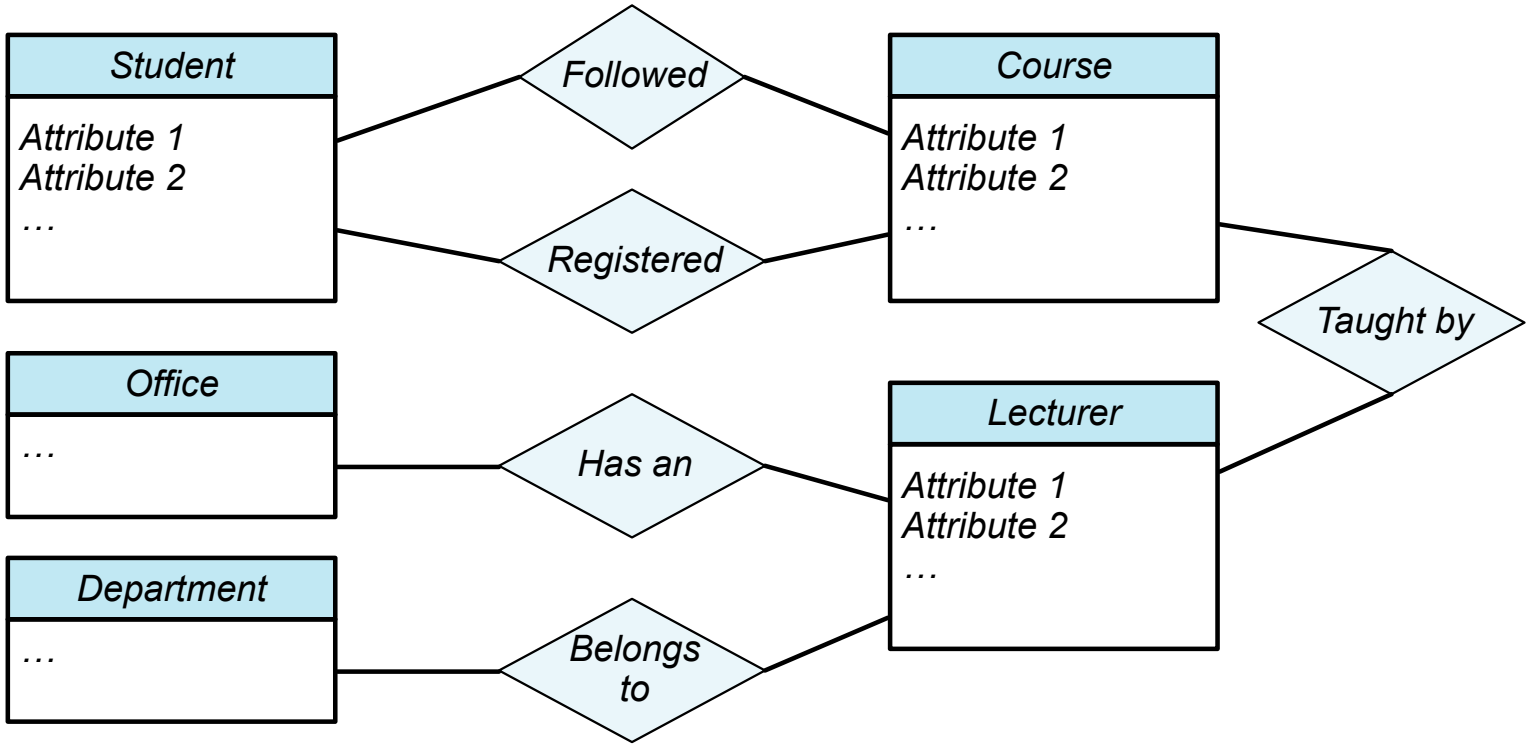
Multiple relations between the same entities

- There can be multiple relations between the same entities
- For instance: student passed a course and student registered for a course



Multiple entities and relations

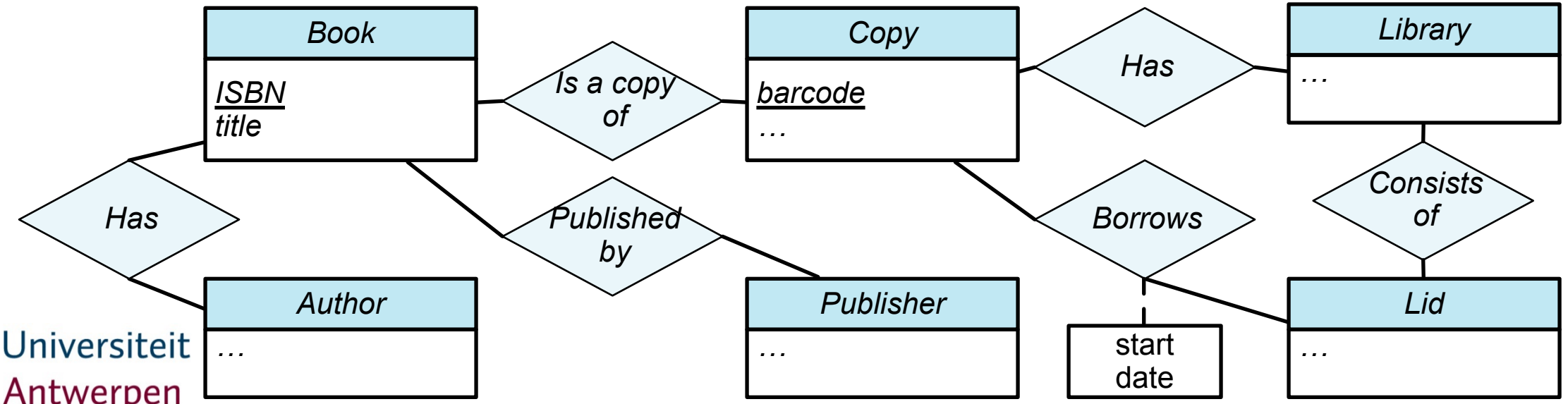
- An ER-diagram will now consist of all entities and their relations in a database.
- E.g: students followed courses taught by lecturers that belong to departments and have an office ; students register for a course



Question

- Translate the following situation in an ER-diagram (using the constructions seen sofar):

A library has copies of books. Copies are identified by a barcode. A book is identified by the ISBN number and has a title, an author, and a publisher. Members of the library can borrow a copy of a book. The start date of the loan is recorded.



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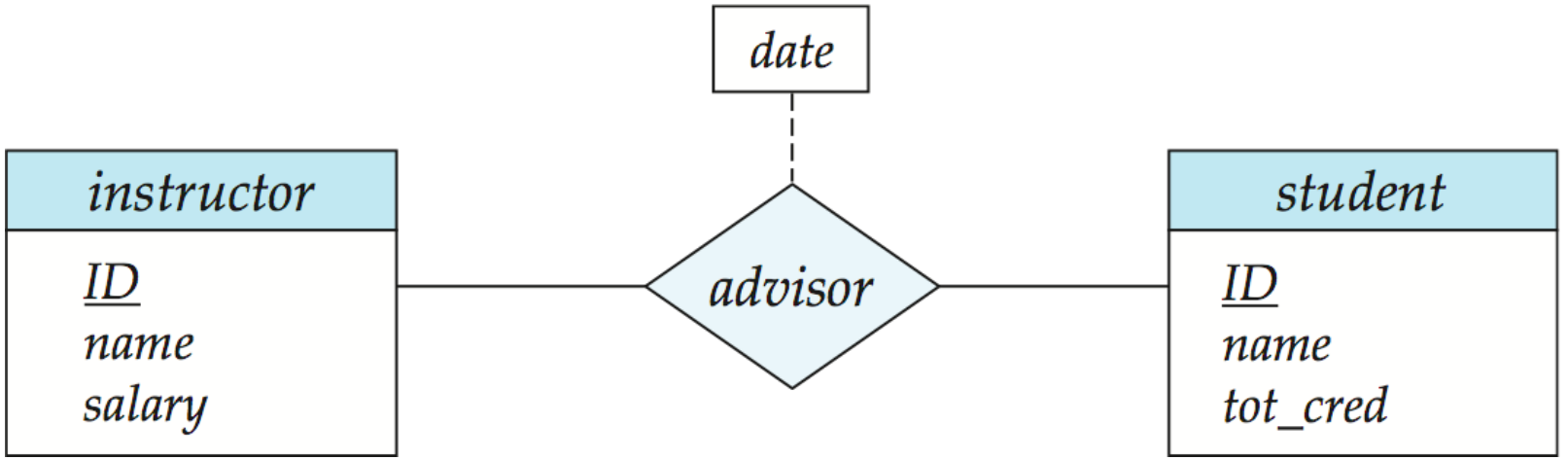
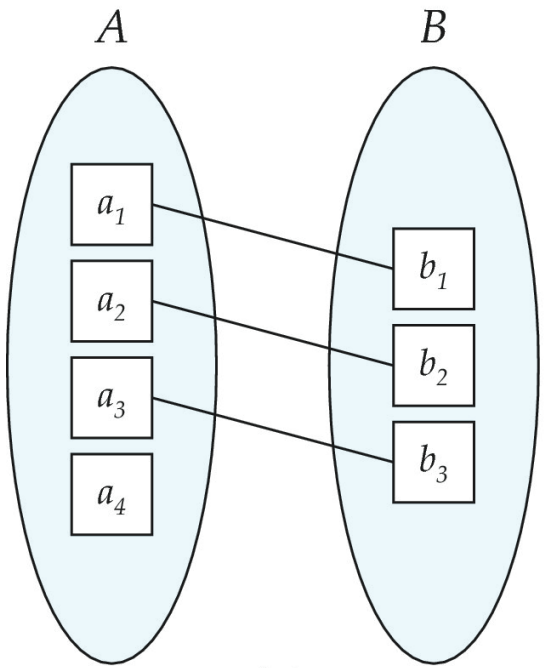


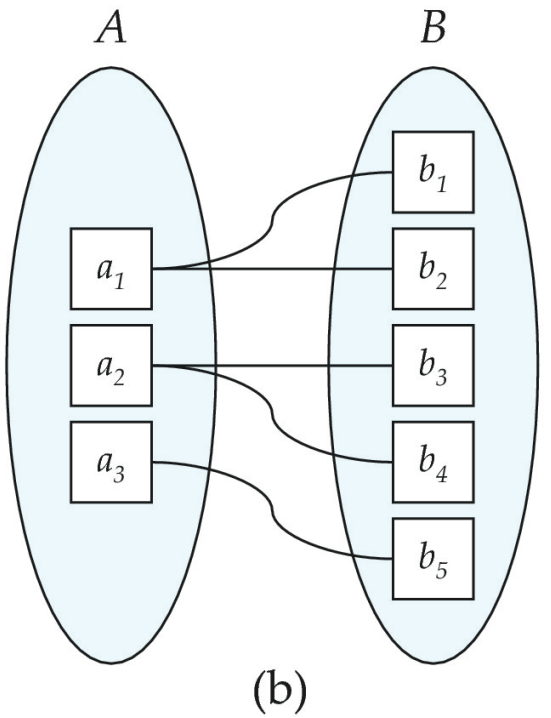
Cardinality Constraints

- 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

One to one and one to many



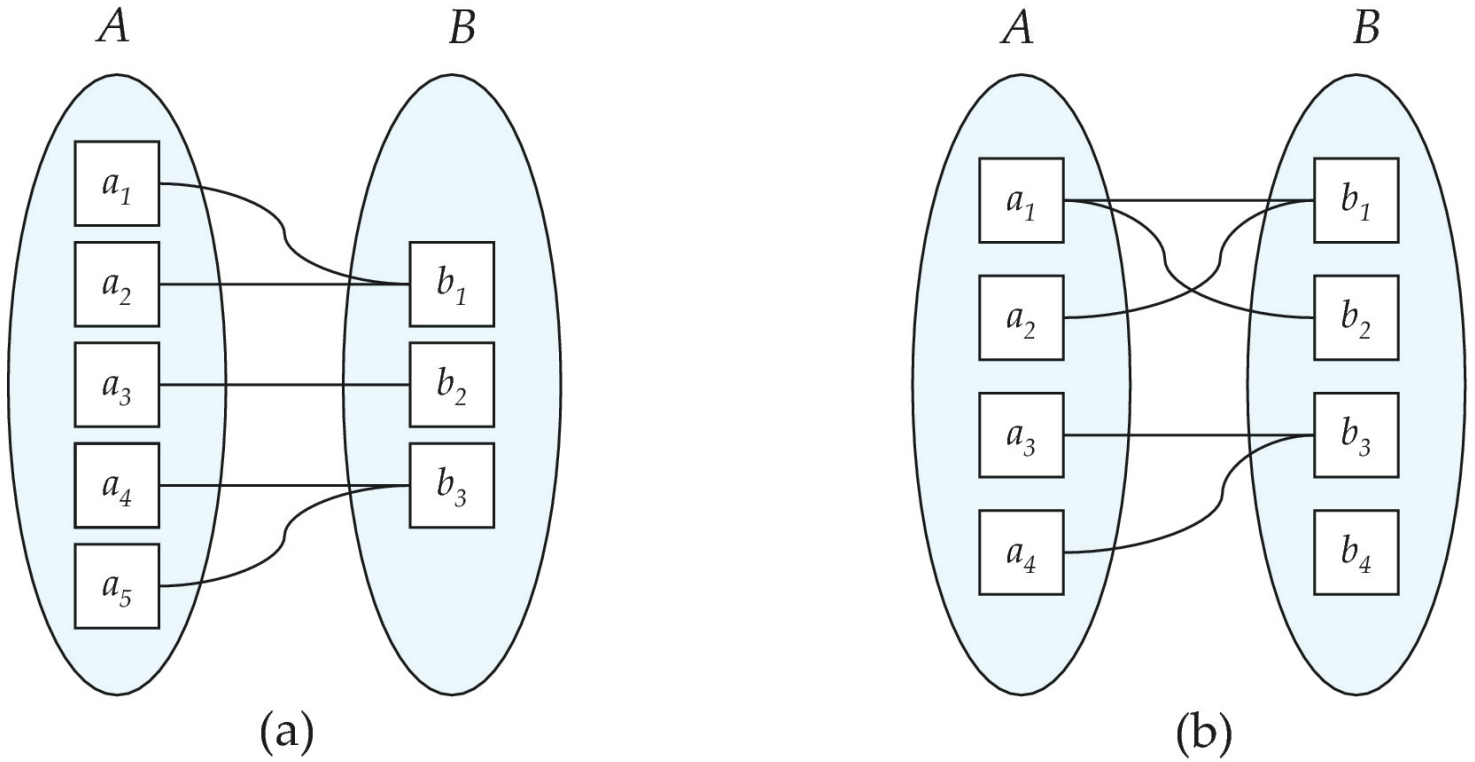
One to one



One to many

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

Many to one and many to many



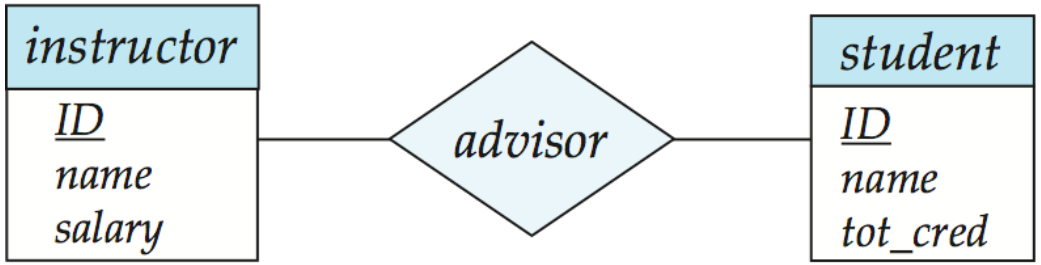
Many to one

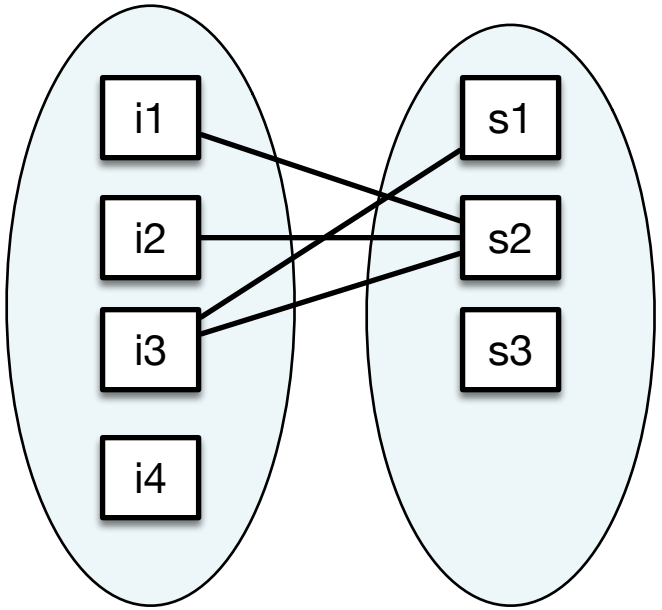
Many to many

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

Many to many relationships

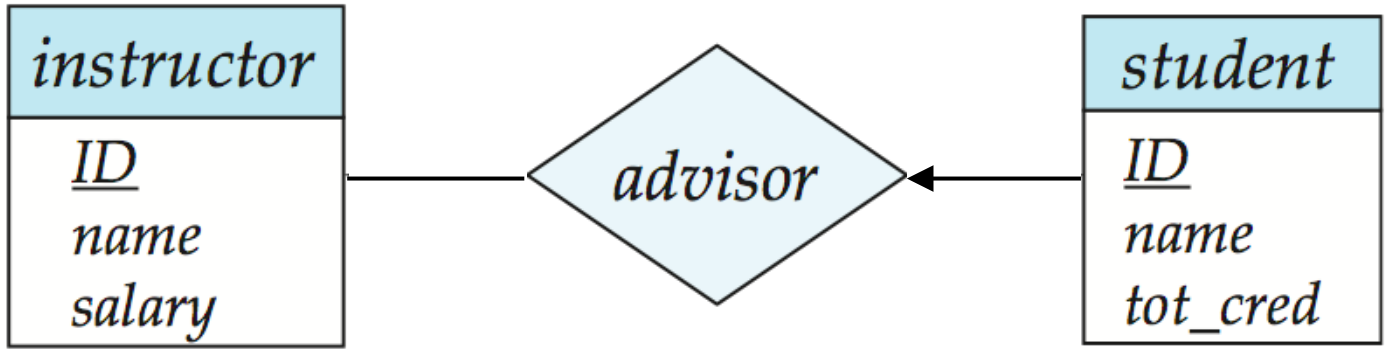
- An *instructor* is associated with several (possibly 0) *students* via *advisor*
- A *student* is associated with several (possibly 0) *instructors* via *advisor*

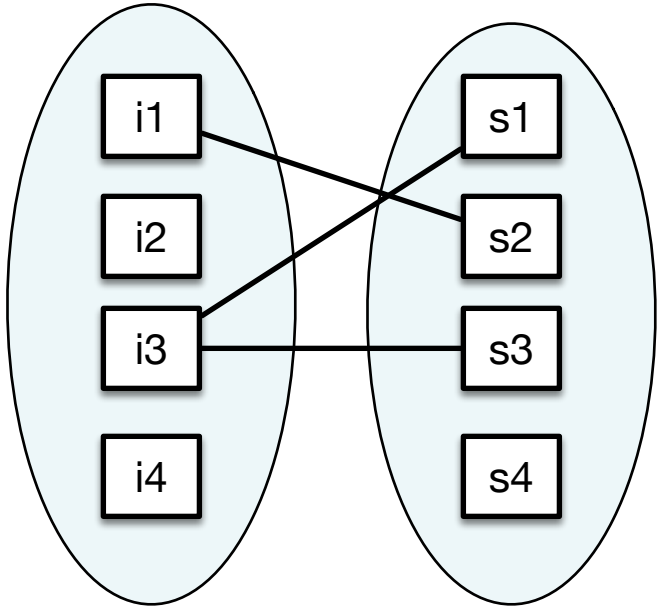




One to many relationships

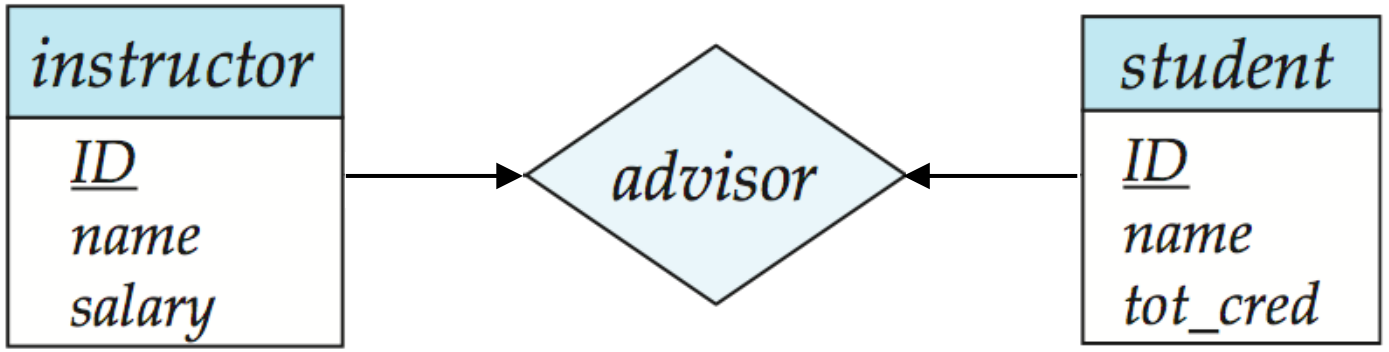
- In the one-to-many relationship between an *instructor* and a *student*
  - an *instructor* is associated with several (including 0) *students* via *advisor*
  - while a *student* is associated with at most one *instructor* via *advisor*

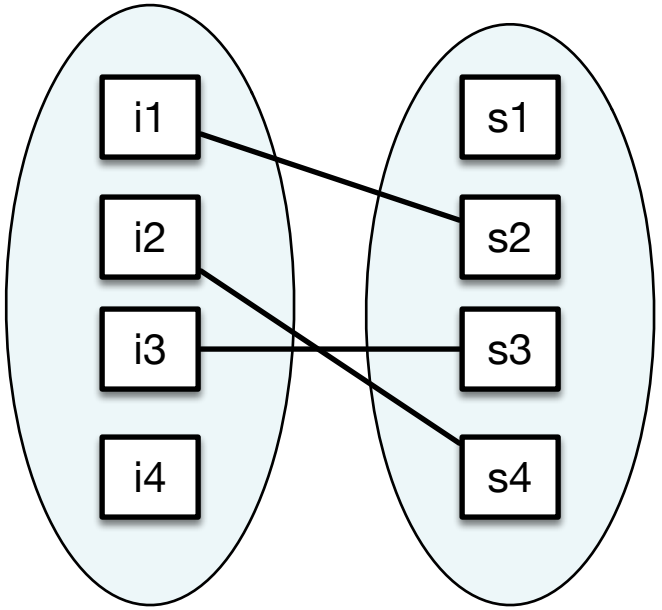




One to one relationships

- In a 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*



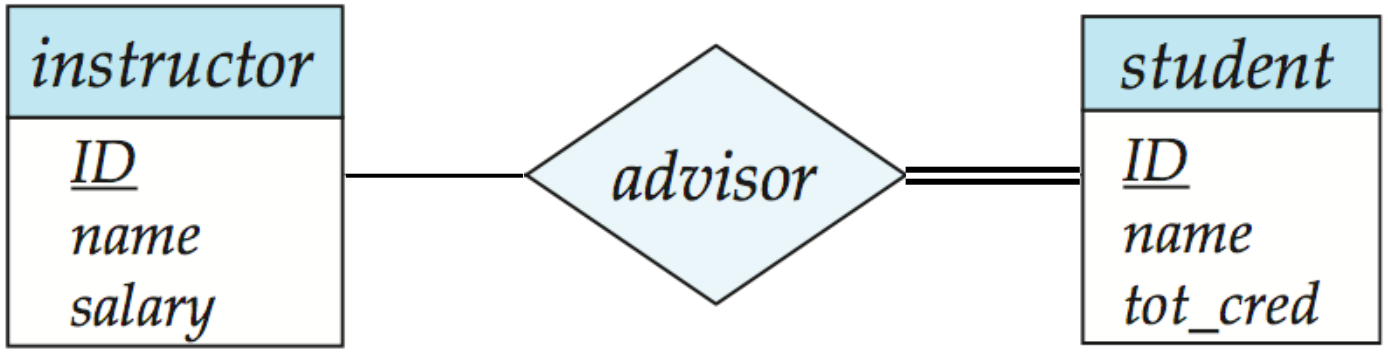


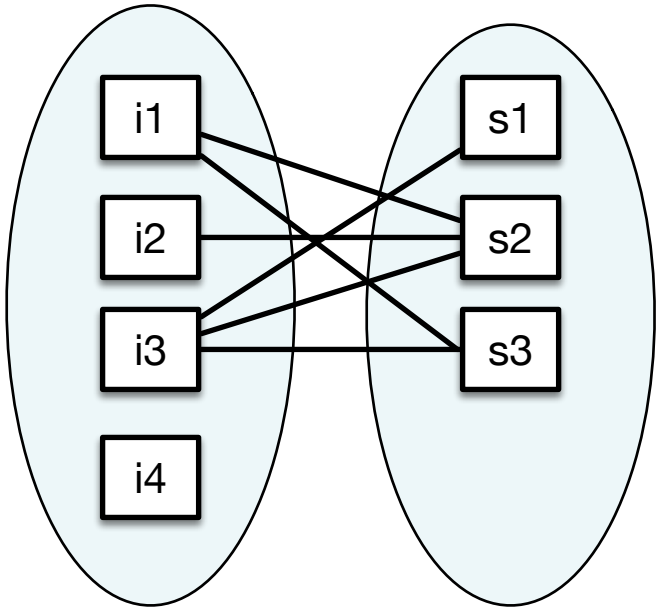
Participation of an Entity Set in a Relationship Set

- **Total** participation (indicated by double line): every entity in the entity set participates in at least one relationship in the relationship set
- **Partial** participation (default): some entities may not participate in any relationship in the relationship set

Example: Participation Constraint

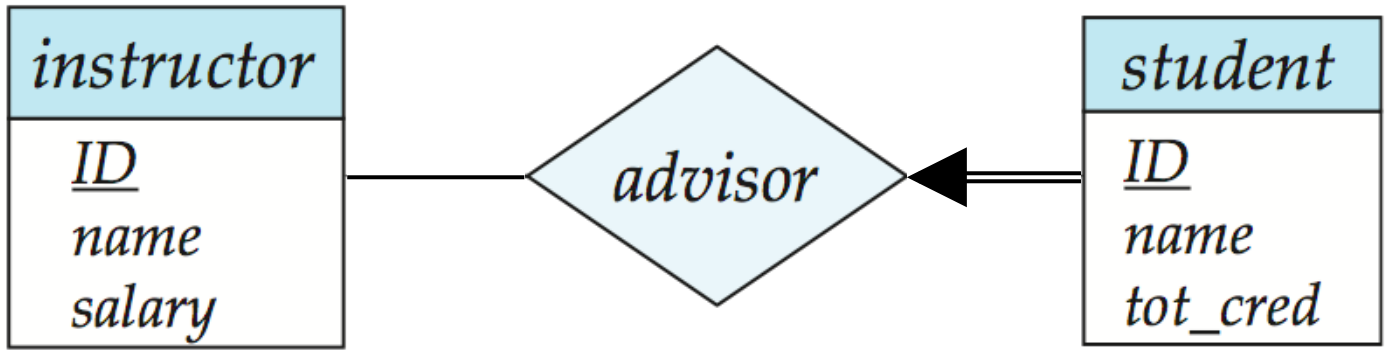
- Every student must have at least one instructor

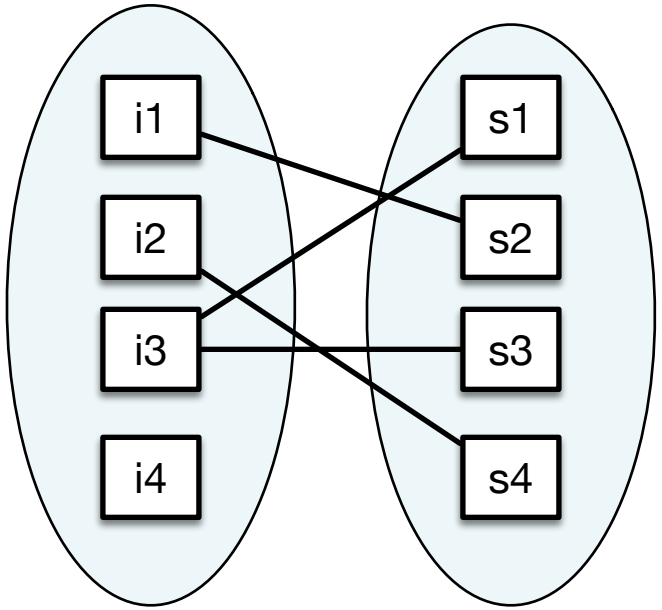




Example: Participation Constraint

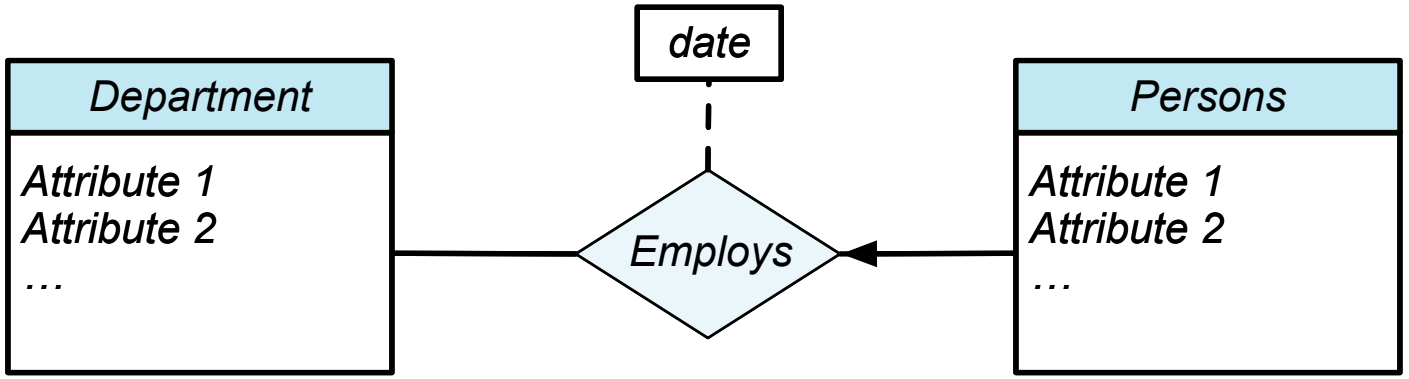
- Every student must **have at exactly one** instructor





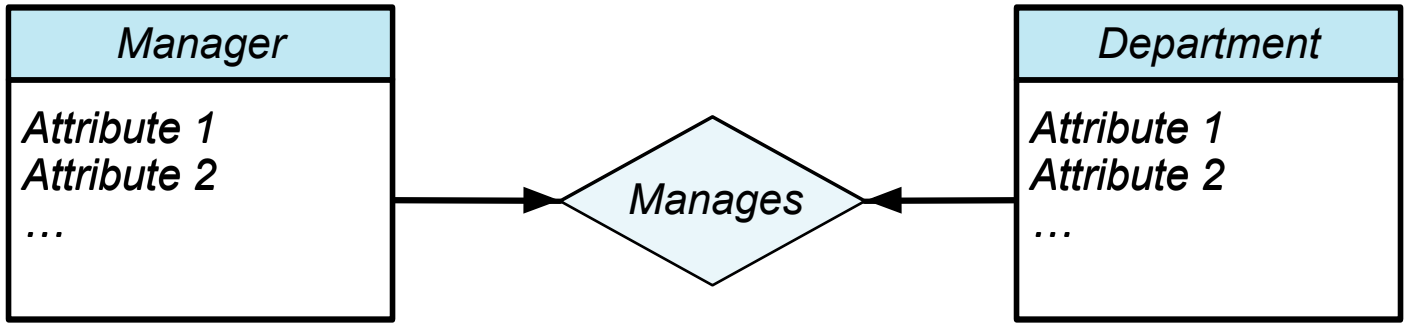
Question

- Make ER-diagrams for:
  - A department employs many persons. A person is employed by, at most, one department.



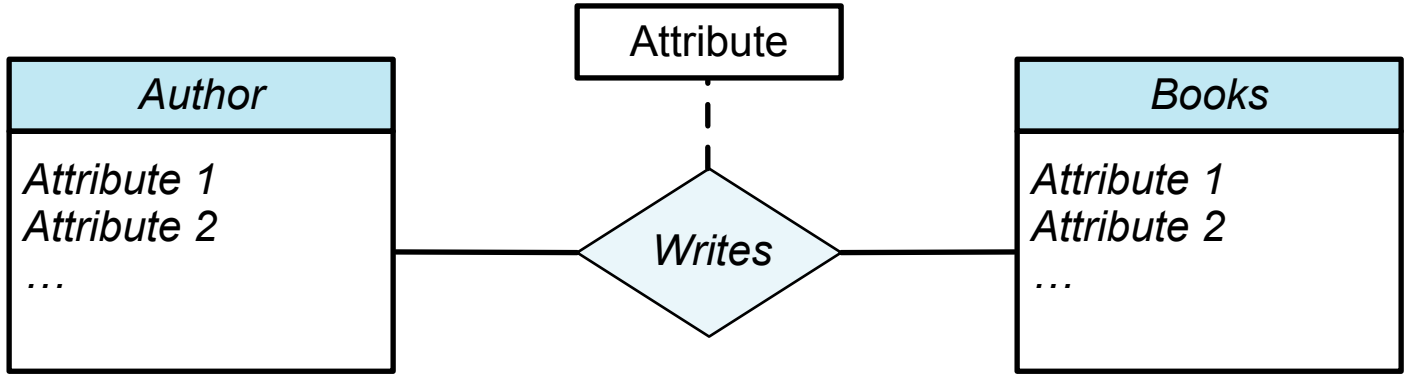
Question

- Make ER-diagrams for:
  - A manager manages, at most, one department. A department is managed by, at most, one manager.



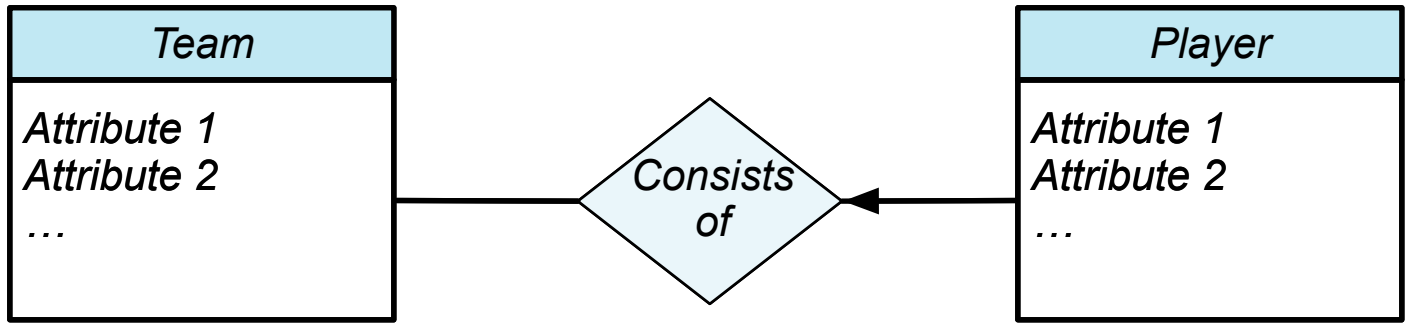
Question

- Make ER-diagrams for:
  - An author may write many books. A book may be written by many authors.



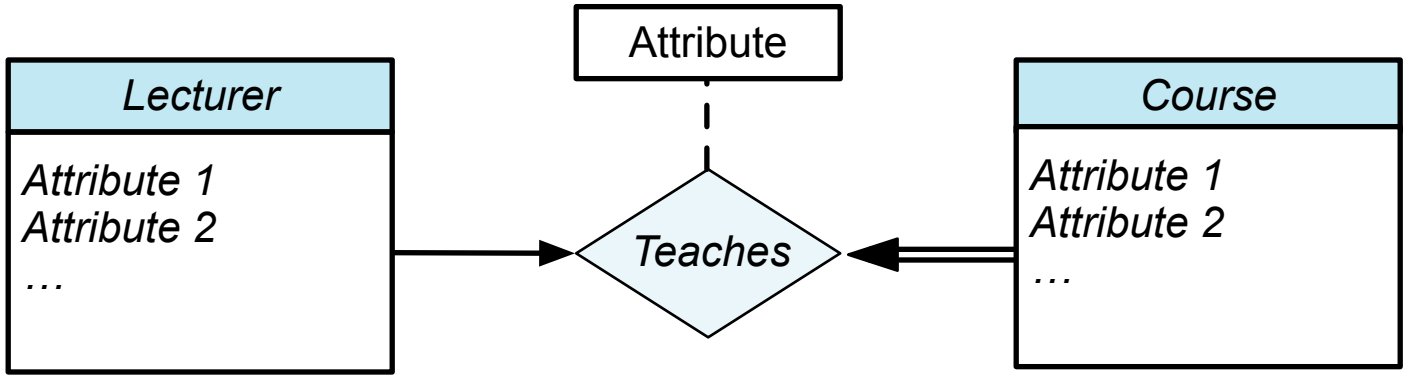
Question

- Make ER-diagrams for:
  - A team consists of many players. A player plays for only one team.



Question

- Make ER-diagrams for:
  - A lecturer teaches, at most, one course. A course is taught by exactly one lecturer.

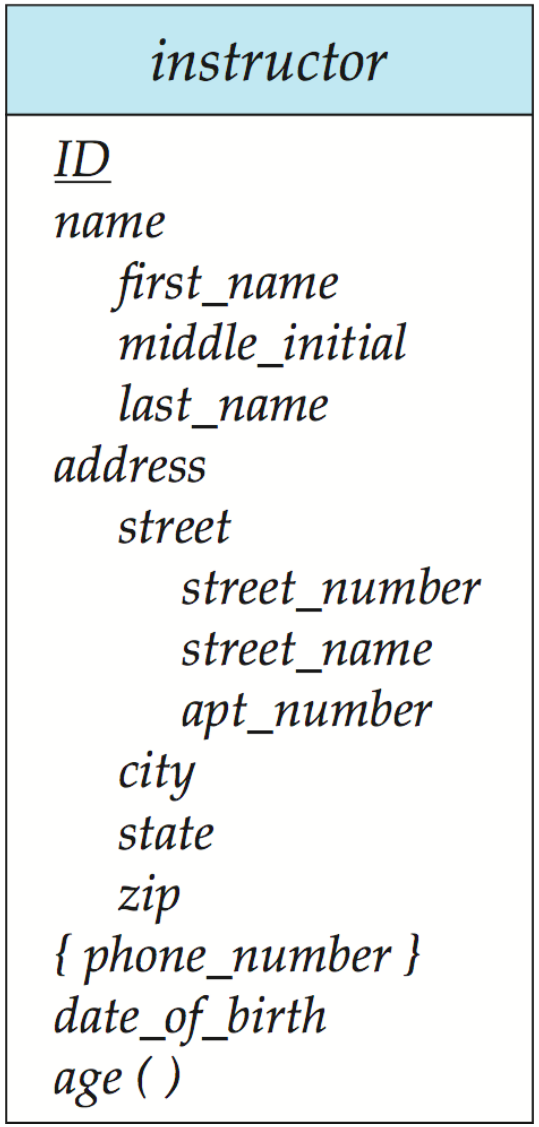


Primary Key

- 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
- Although several candidate keys may exist,
  one of the candidate keys is selected to be the primary key.

- The primary key will play a very important role in the database
  - Used to identify the instances of an entity

Example E-R Diagram With Composite, Multivalued, and Derived Attributes



Question

- Consider the following example. Identify the entities. What would be a good key for these entities? If information is missing, make assumptions to fill in the blanks.
  - A course has one course offering every year, either in the spring or autumn semester. Courses have a unique course identifier and a name. A course name is not necessarily unique. For every course offering there is exactly one responsible lecturer. The responsible lecturers are employees of the department. There are six different departments. All employees have an employee number.
  - Entities: course, course_offering, lecturer, employee, department
  - Keys: course -> cid ok, name not ok, (cid, name) superkey; course_offering-> key for lectures; Lectures-> key for employee; Employee->Eid, Department->Did

Question

- Every employee has a unique ID. Employees have one name, gender, address, department, account, salary.
- Addresses are not necessarily unique; there may be multiple employees that share the same address. It is, however, forbidden for two employees with the same address to work at the same department (e.g. to avoid nepotism).
- The bank account of a person is unique; every person has one account, and no two employees may have the same account (e.g., due to legal restrictions salaries need to be paid on a personal account).

List all candidate keys of the entity “Employee”

Question

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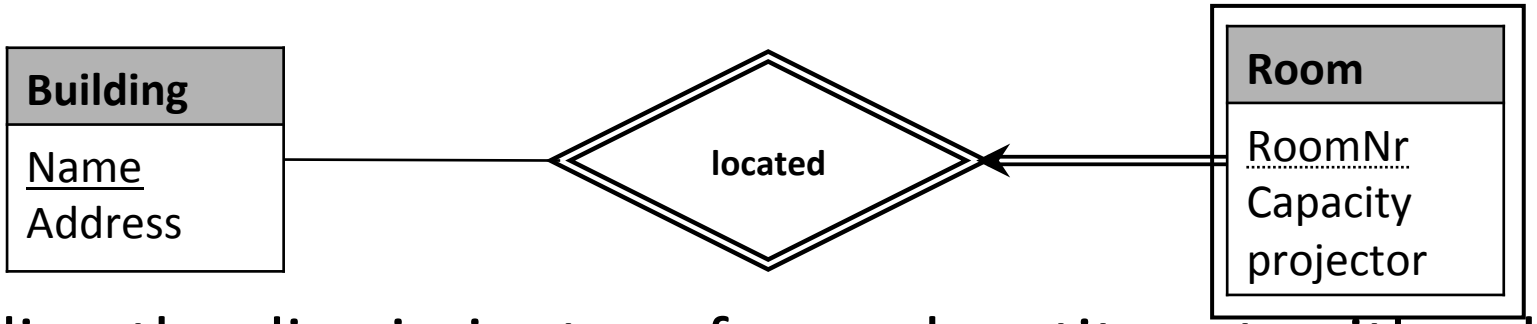
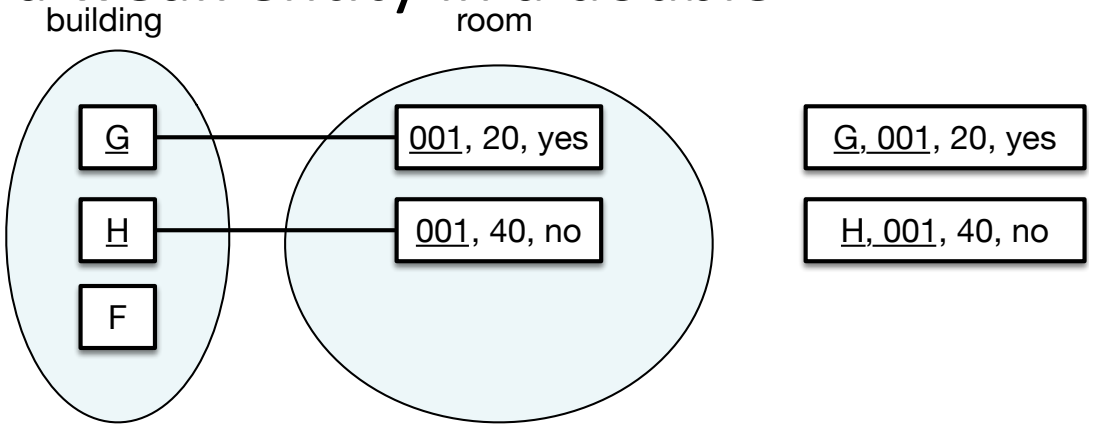
List all candidate keys of the entity “Employee”

Weak Entity Sets

- Some entities (W) need other entity (O) to define their identity
  - Every entity w related to exactly one o



- 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.



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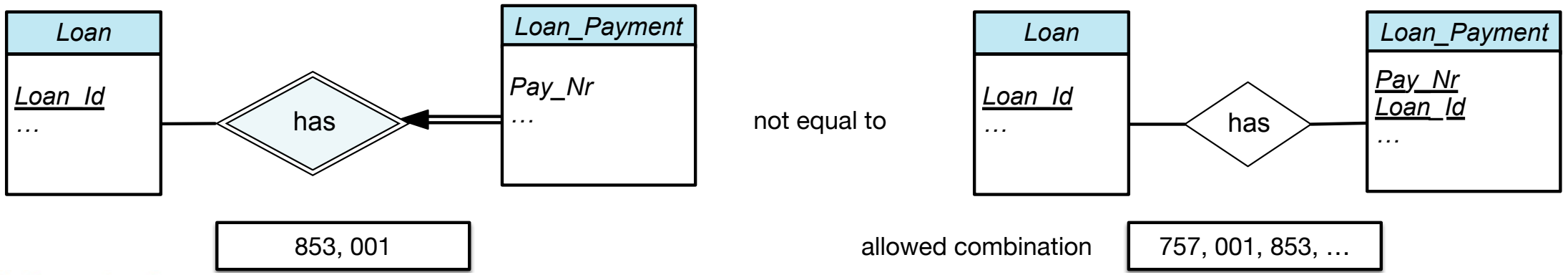
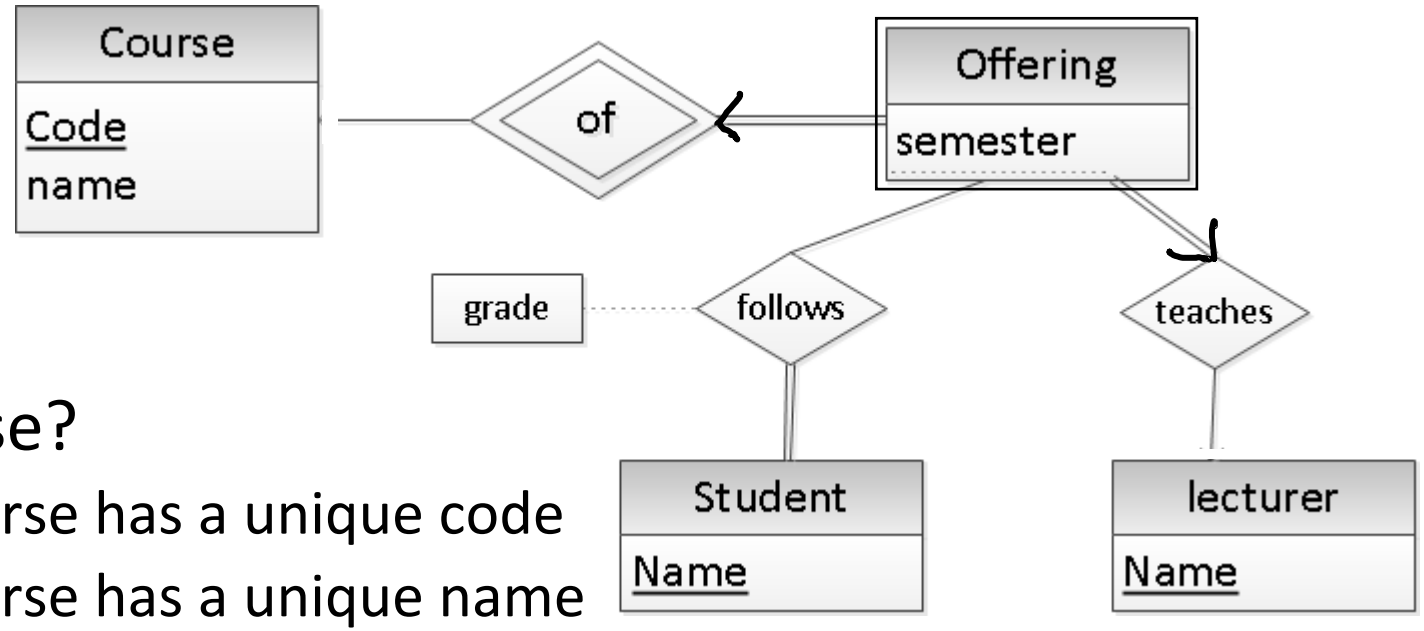
More on Weak Entity Sets

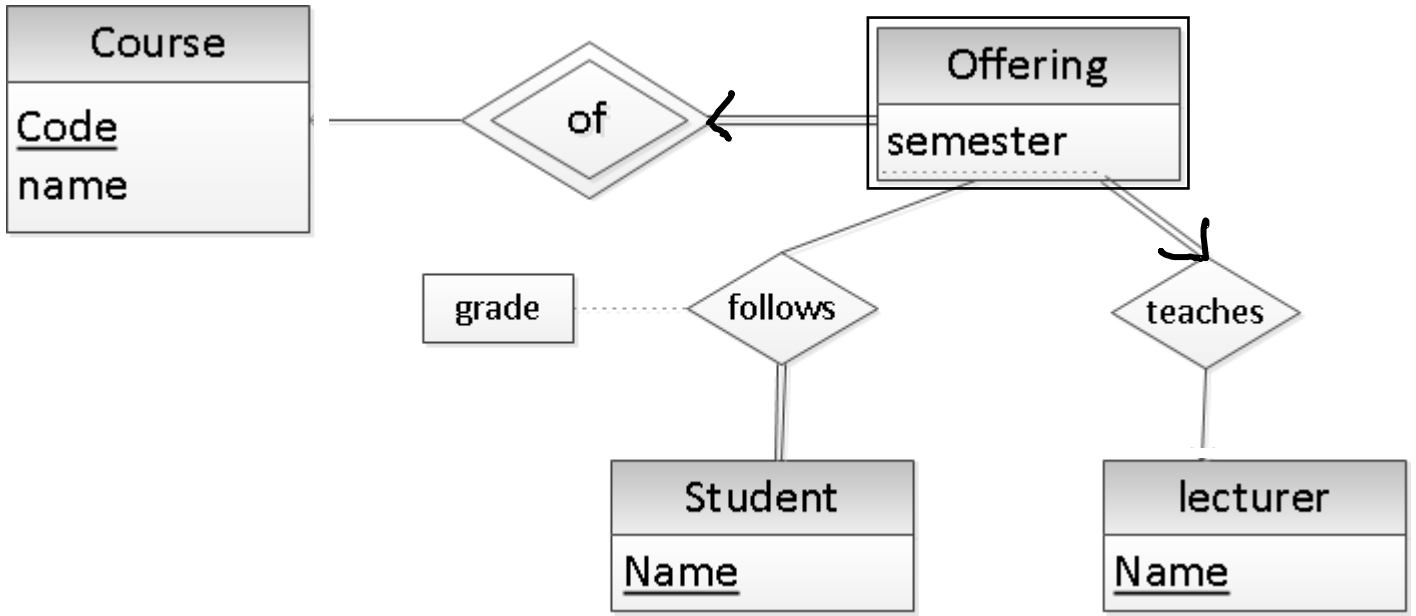
- In a bank, a *loan* is a strong entity and a *loan_payment* can be modeled as a weak entity
- The discriminator of *loan_payment* would be *payment_number*
- If we model *loan_payment* as a strong entity we would model *loan_id* as an attribute.
  Then the relationship with *loan* would be implicit in the *loan_id* attribute



Exercise



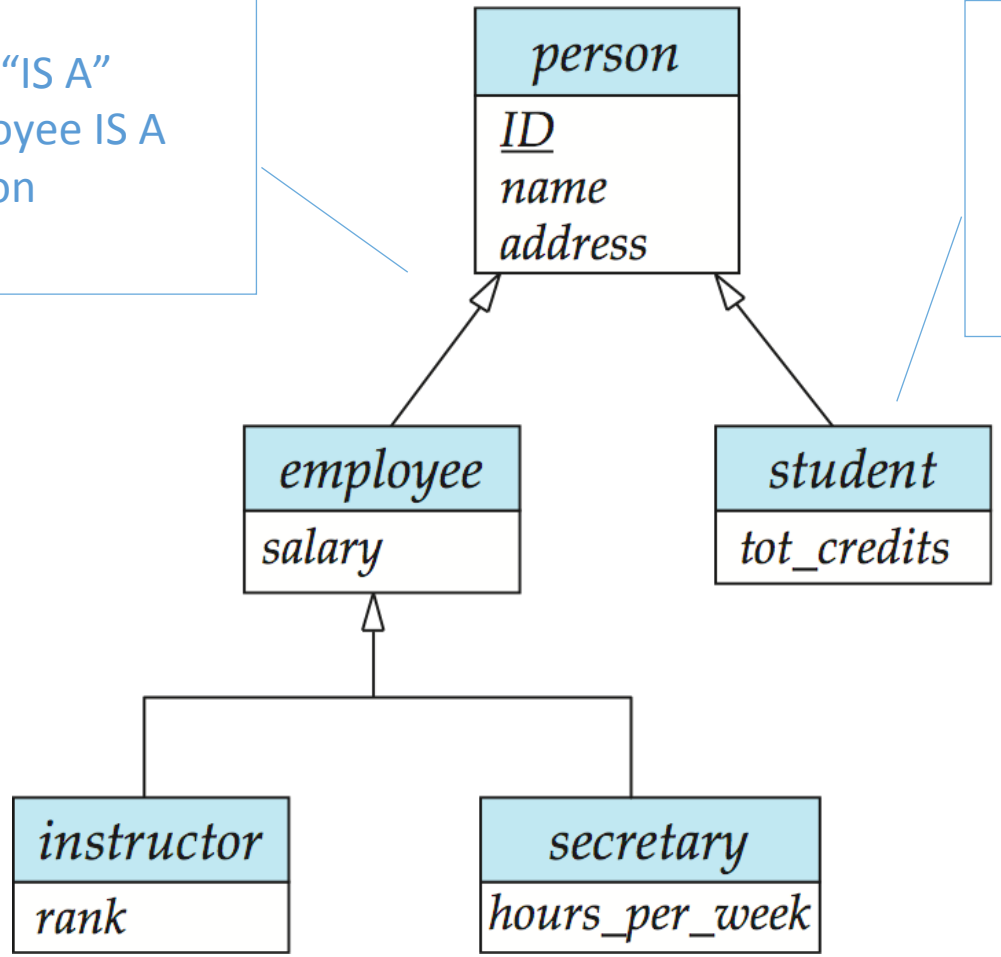
- True or False?
  - Every course has a unique code
  - Every course has a unique name
  - A student has to follow at least one course
  - There can be multiple course offerings per course and semester, as long as they are taught by different lecturers
  - There may be courses without students
  - A student always has a unique grade per course offering he or she followed



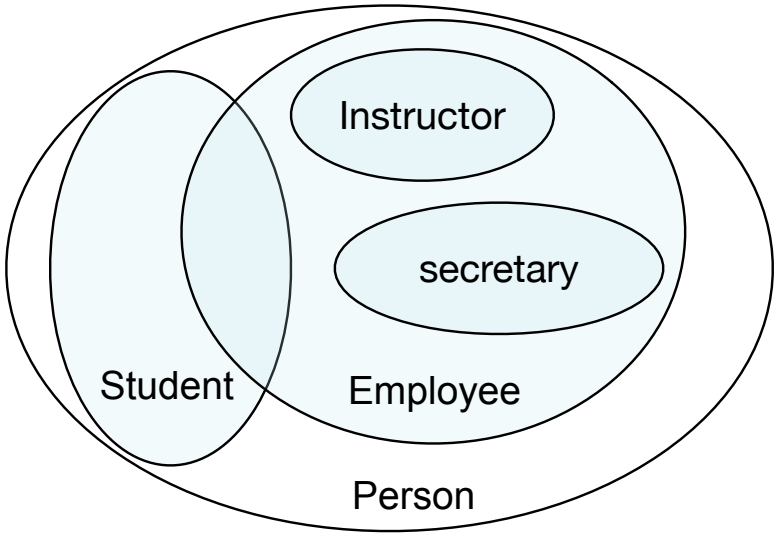
- Every course has a unique code
- Every course has a unique name: (011,Intro db), (012,Intro db) ok in Course
- A student has to follow at least one course: (student-at least one offering − at least one course)
- There can be multiple course offerings per course and semester, as long as they are taught by different lecturers: (semester,code) are key. (semester, name) not key.
- There may be courses without students: sure no restrictions
- A student always has a unique grade per course offering he or she followed: (name,semester) at most one…

Extended E-R Features: Specialization

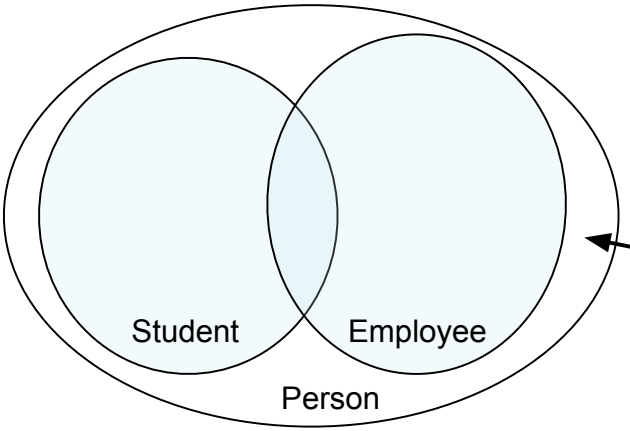
Read as: “IS A”
Every Employee IS A person



No primary keys (inherited from person)



Specialization



empty

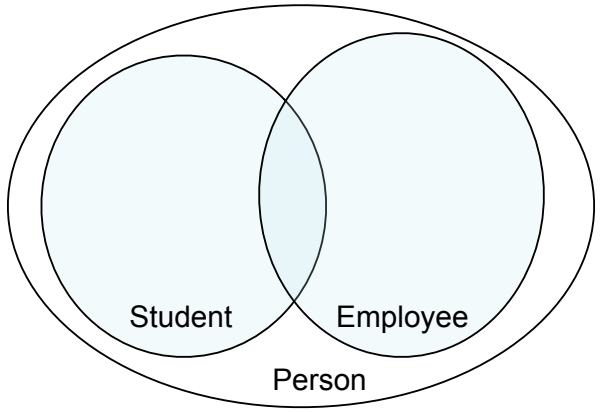
total

Person
SSN
Name

Employee
Salary

Student
GPA

Every person is either an Employee, a Student, or both



Person
SSN
Name

Employee
salary

Student
GPA

Some persons are also Employee and/or Student

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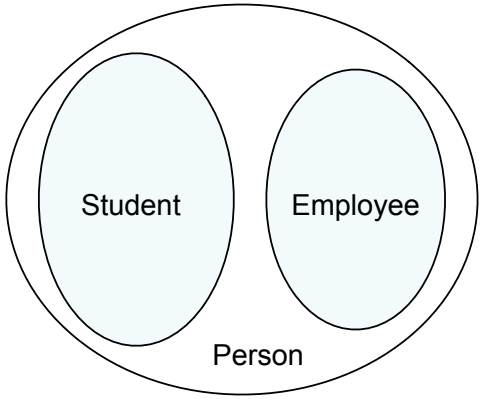
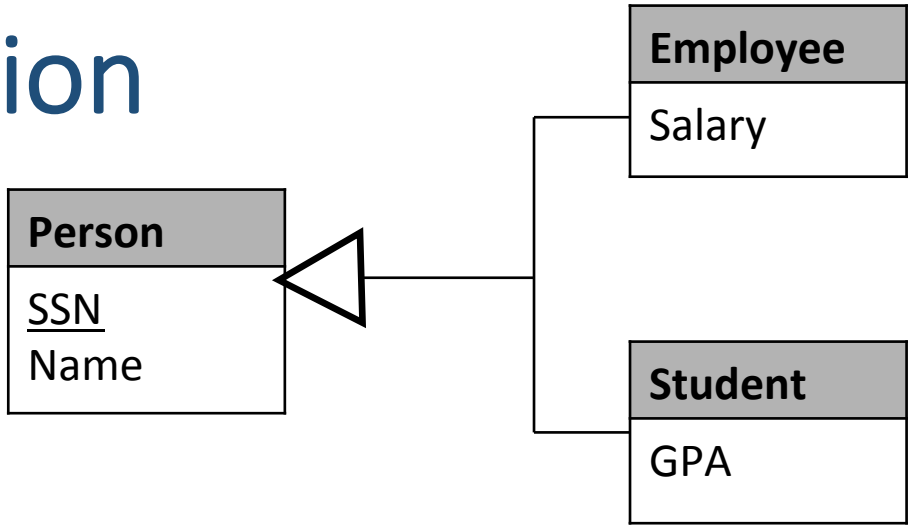
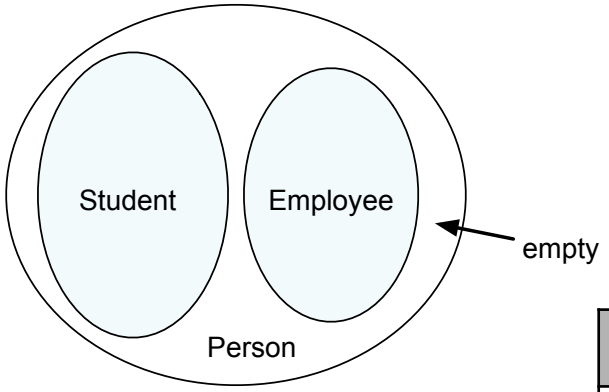
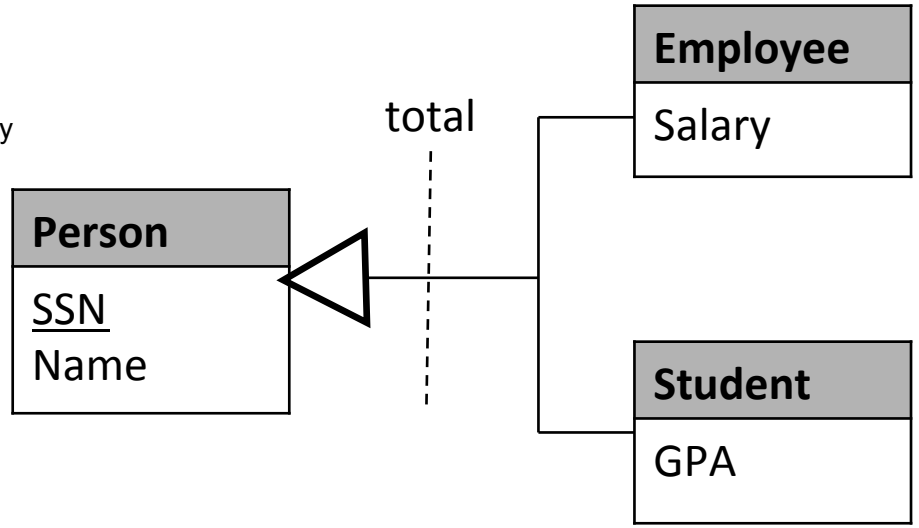
Specialization





Some persons are Employee or Student, but never both





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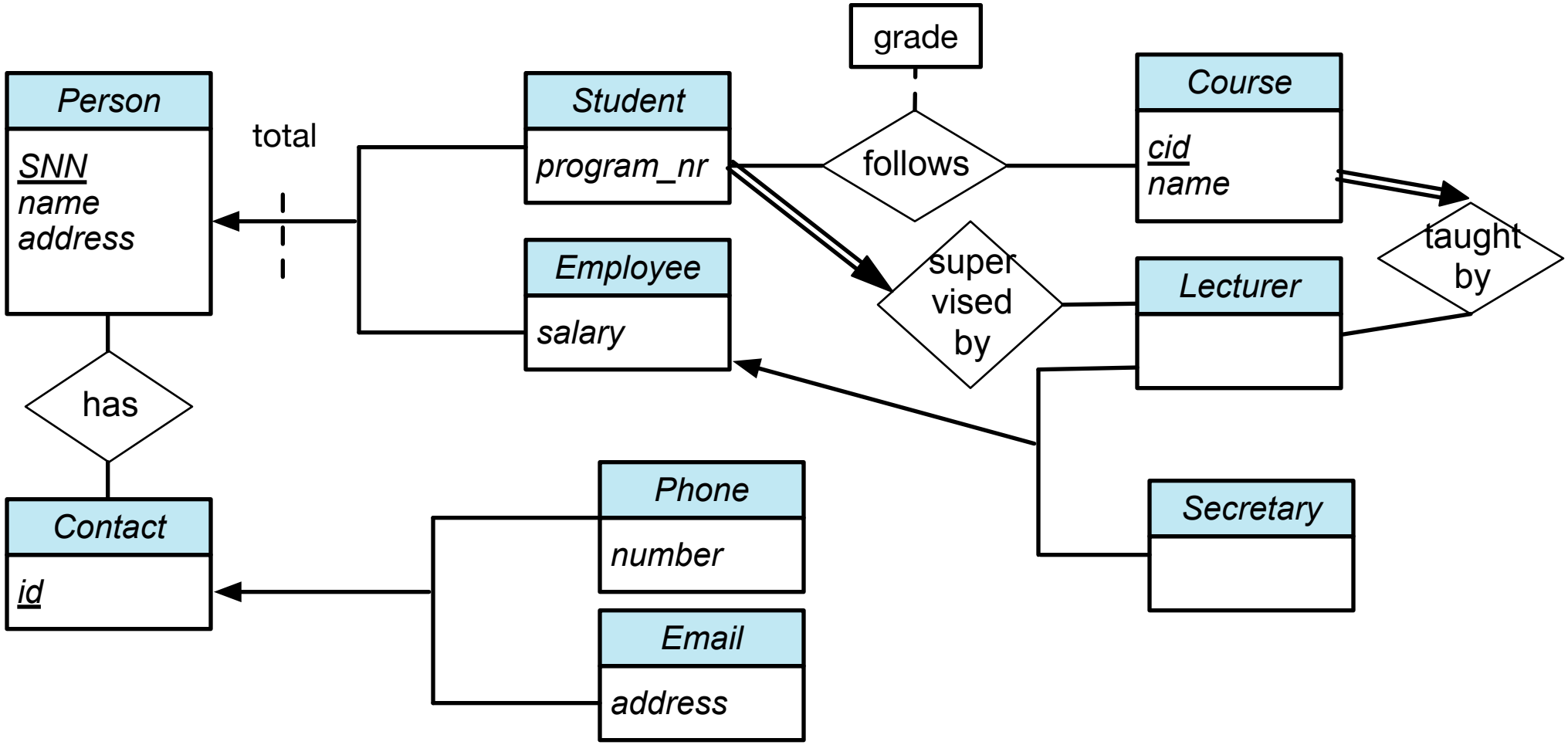
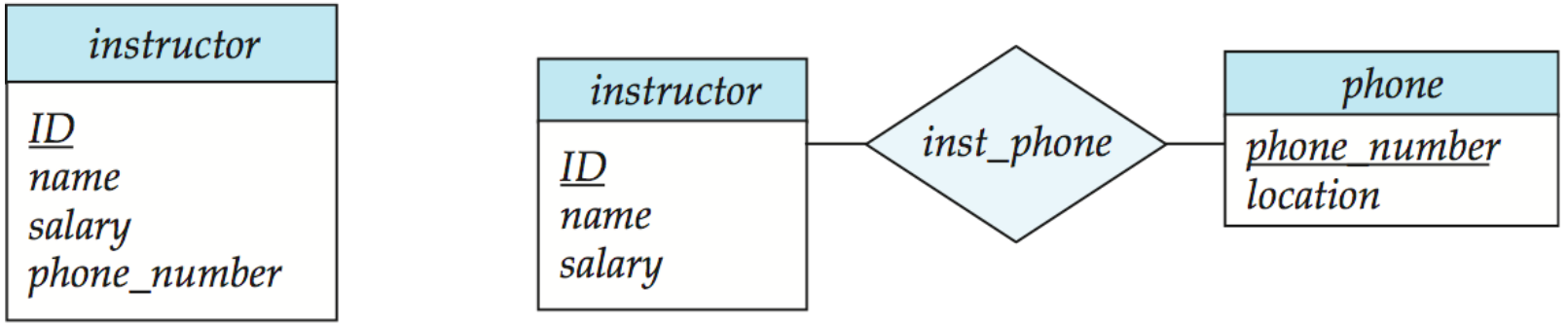

Person
SNN
name
address
total
Student
program_nr
Employee
salary
grade
follows
Course
cid
name
taught by
super vised by
Lecturer
has
Contact
id
Phone
number
Email
address
Secretary

Side note on Design Issues

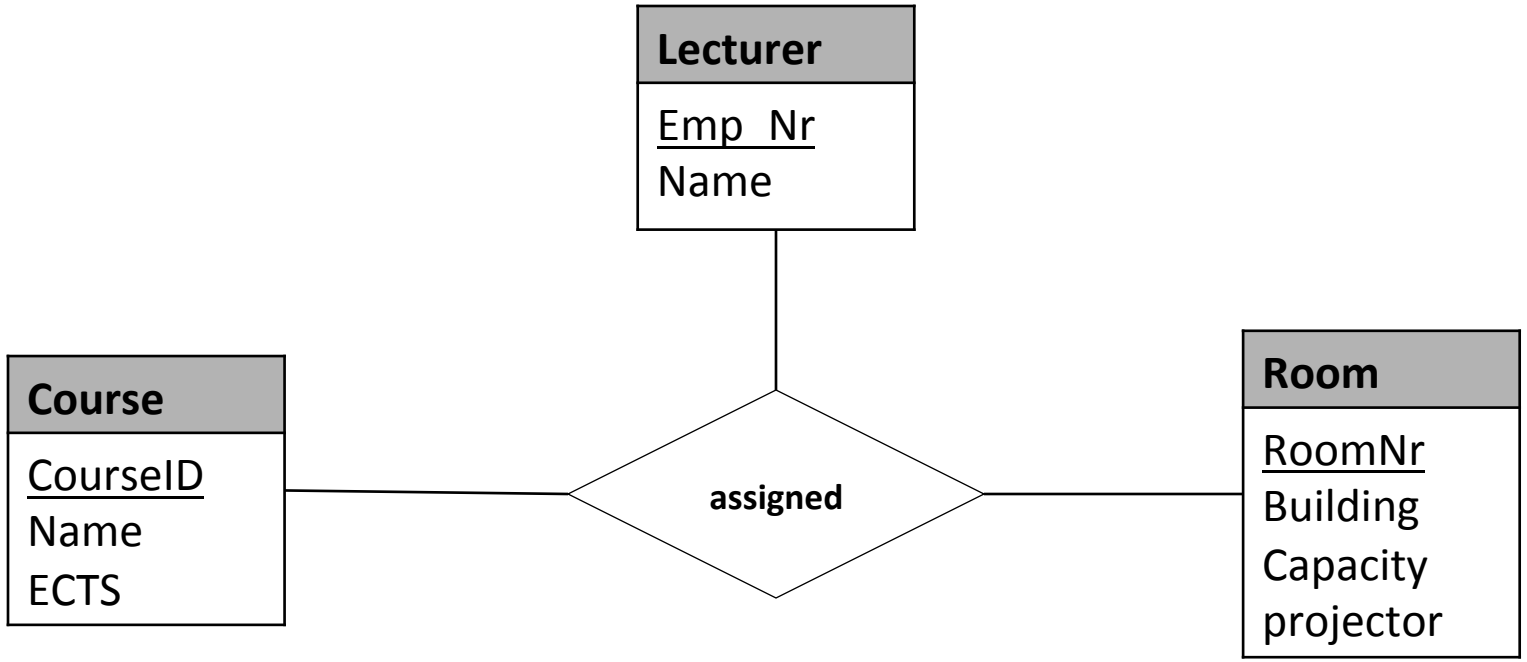
- Use of entity sets vs. attributes
  Choice mainly depends on the structure of the enterprise being modeled, and on the semantics associated with the attribute in question.



Use of phone as an entity allows extra information about phone numbers (plus multiple phone numbers)

Converting Non-Binary Relationships to Binary Form

- It is always possible to translate a ternary relation to three binary ones:



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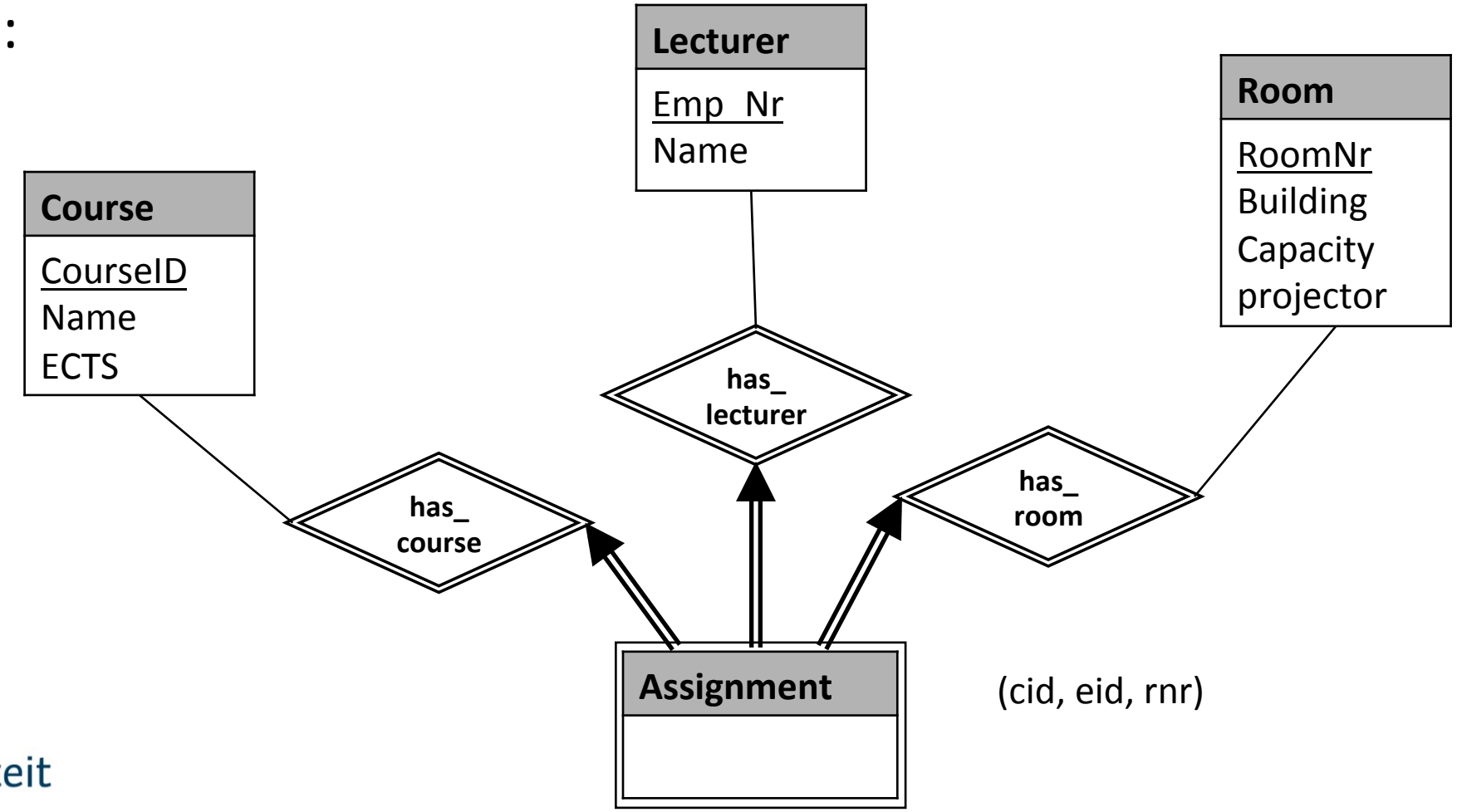

Summary: ER Modelling

- Conceptual language to express requirement analysis
  - Entities with attributes
  - Relationships between entities
  - Participation constraints
  - ISA relationships

- Next lecture we will see the relational model and how to translate ER-diagrams into the relational model