E-R Diagram: Subclass, E-R to relational design

CS 4750 Database Systems

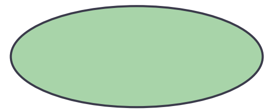
[A. Silberschatz, H. F. Korth, S. Sudarshan, Database System Concepts, Ch.6]
[C.M. Ricardo and S.D. Urban, Database Illuminated, Ch.3]

E-R Diagram: Building Blocks

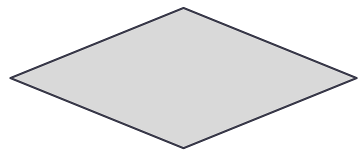
revisit

(strong) Entity set

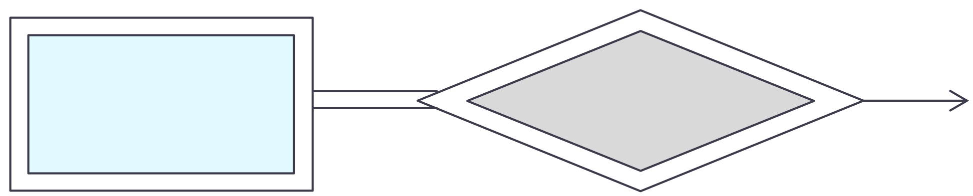
Attribute



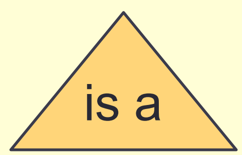
Relationship



Weak entity



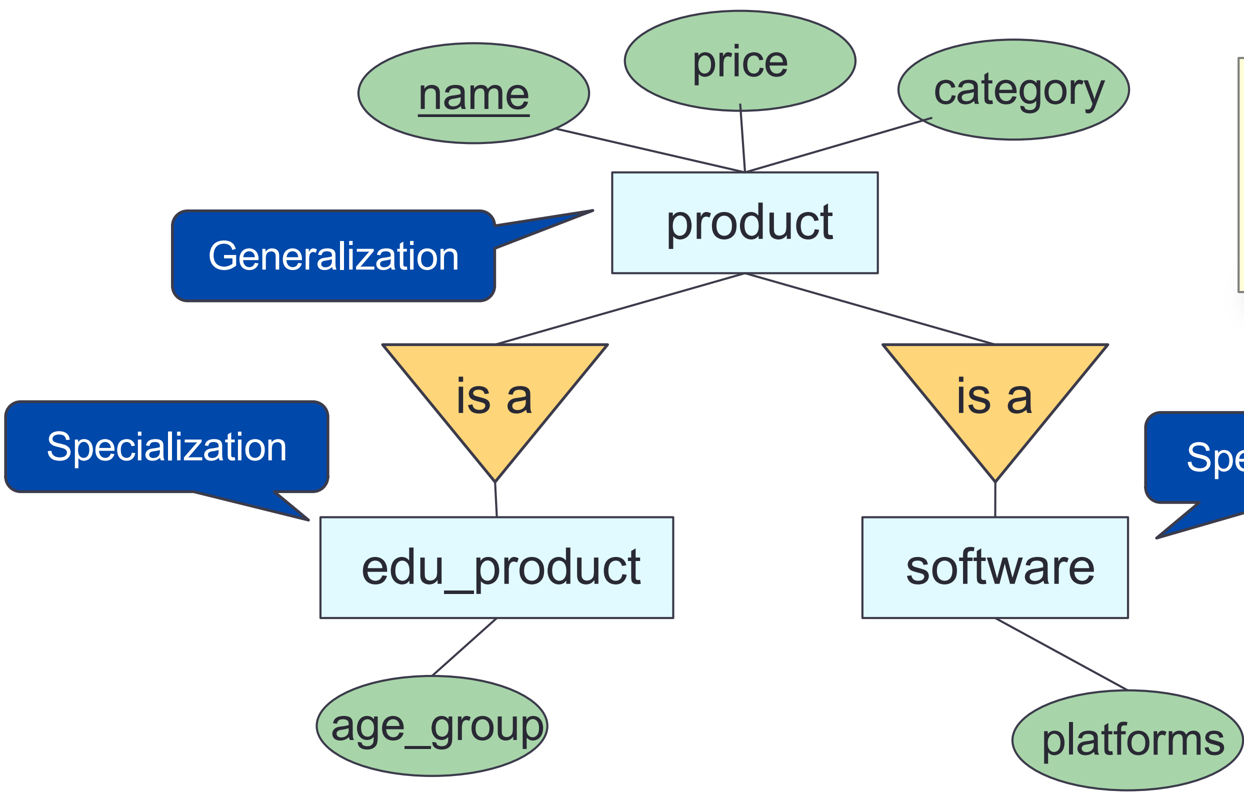
Subclass



Note: colors are not part of E-R Diagram. They simply are used to increase readability.

Subclassing

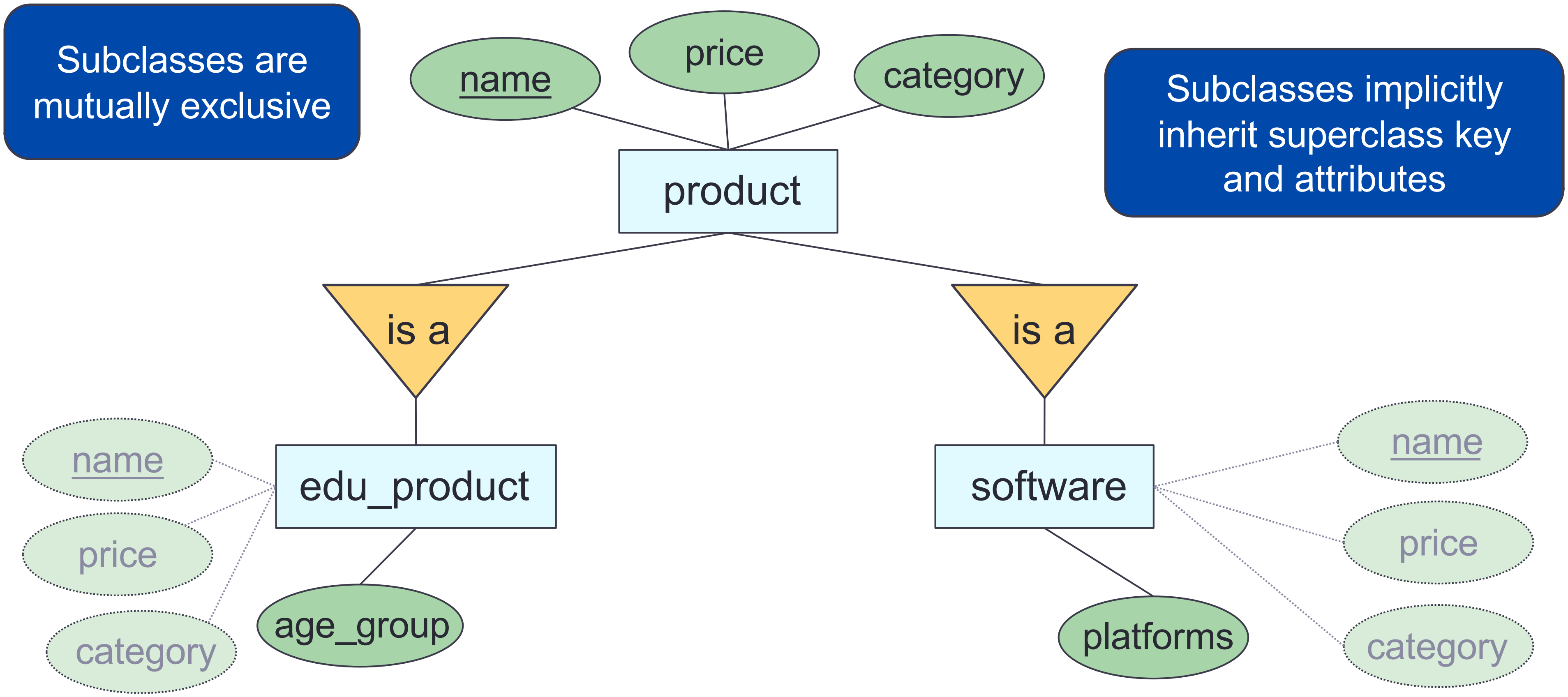
- An entity set may contain entities that have special properties not associated with all members of the set
- Subclasses ~ special-case entity sets
- Isa (or Is-a) ~ special kind of relationship (one-to-one)



Similar to classes in OO (super-classes and sub-classes)

The triangle points to the specialization

Subclassing



Generalization / Specialization
The triangle points to the specialization

Let's try: Subclassing (Movies)

Consider the following (partial) description of a movie scenario.

Each movie has a *title* and *year*; *title* and *year* together uniquely identify the movie. *Length* and *genre* are maintained for each movie.

Among the special kinds of movies, we might store in our database are cartoons and murder mysteries.

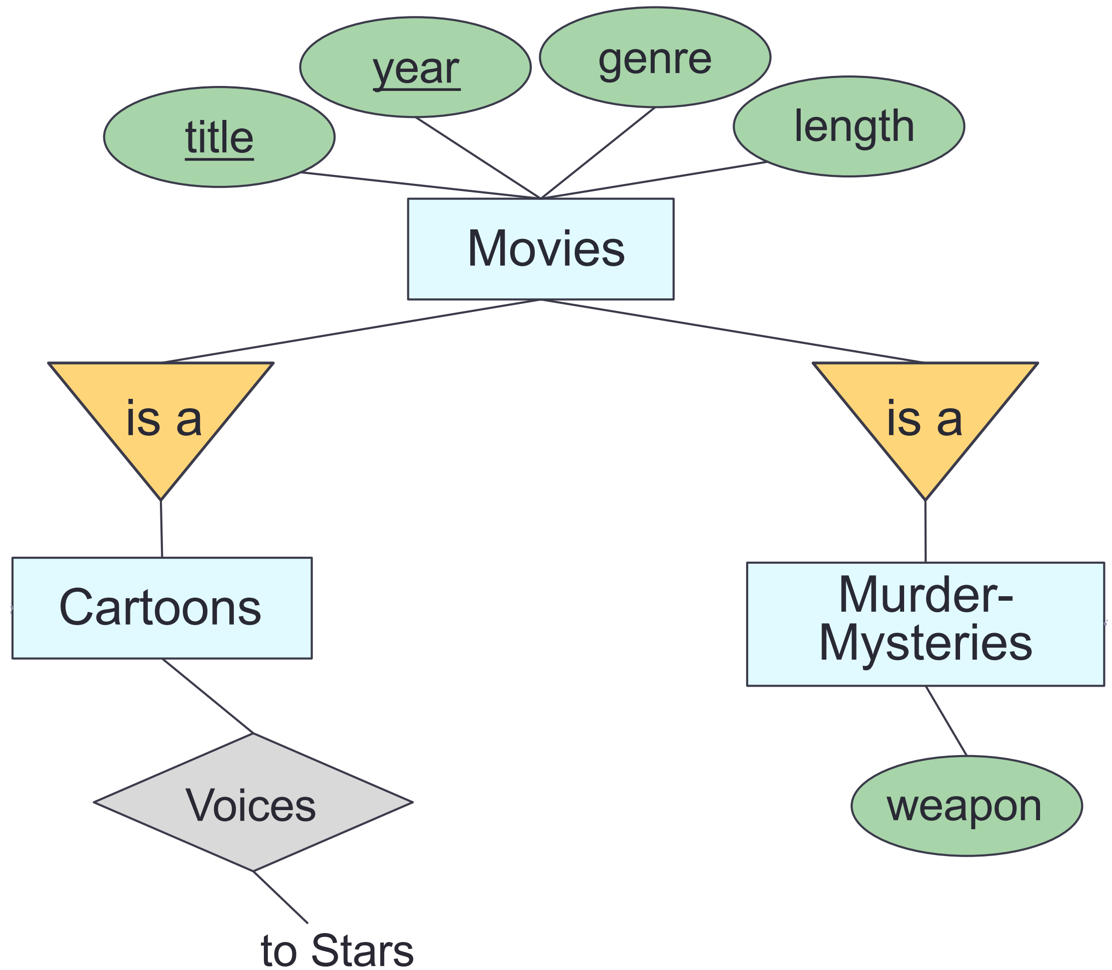
A cartoon has, in addition to the attributes and relationships of *Movies*, an additional relationship called *Voices* that gives us a set of stars who speak, but do not appear in the movie. Movies that are not cartoons do not have such stars.

Murder-mysteries have an additional attribute *weapon*.

Draw an E-R diagram to show the connections among the three entity sets: *Movies, Cartoons,* and *Murder-Mysteries.*

Let's try: Subclassing (Movies)

Draw an E-R diagram to show the connections among the 3 entity sets: *Movies, Cartoons,* and *Murder-Mysteries* (from previous page)



Done with the building blocks

Let's transition to design decision

and converting E-R diagram into Relational designs

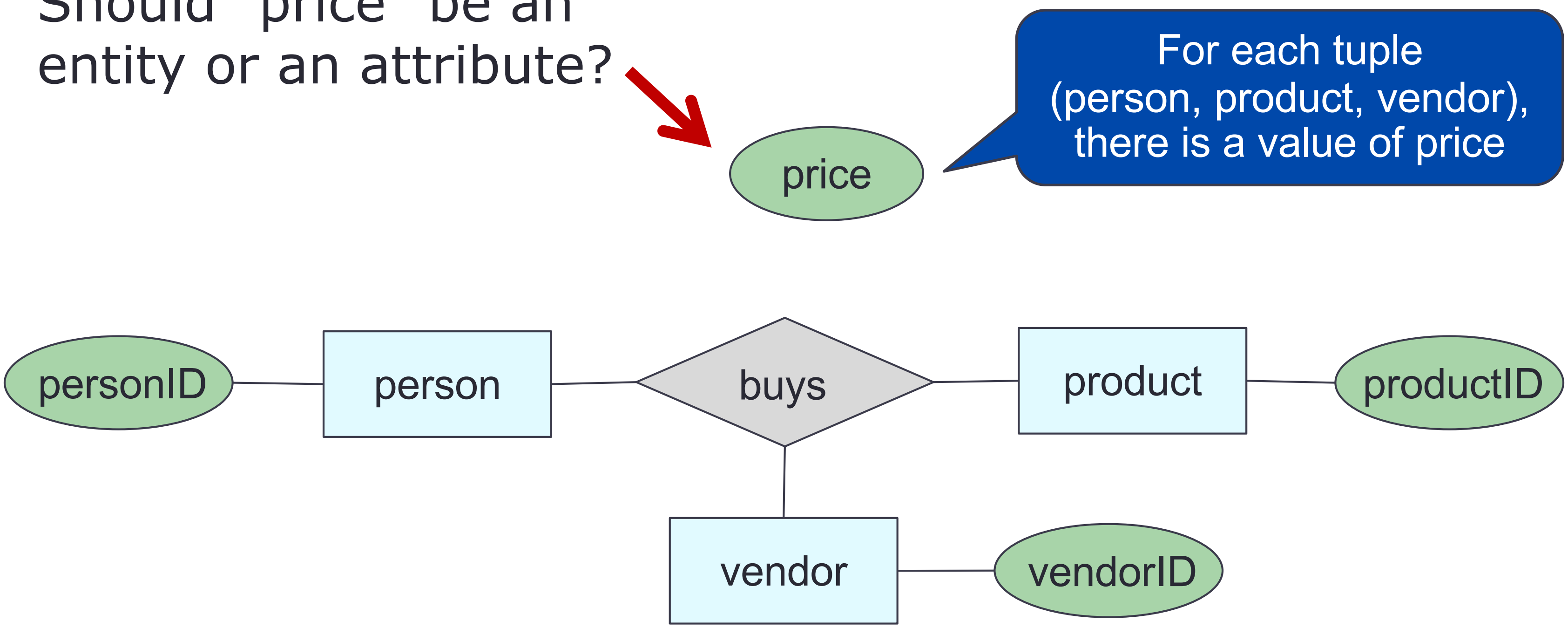
Recap: Entity vs. Attribute

What are main differences between entities and attributes?

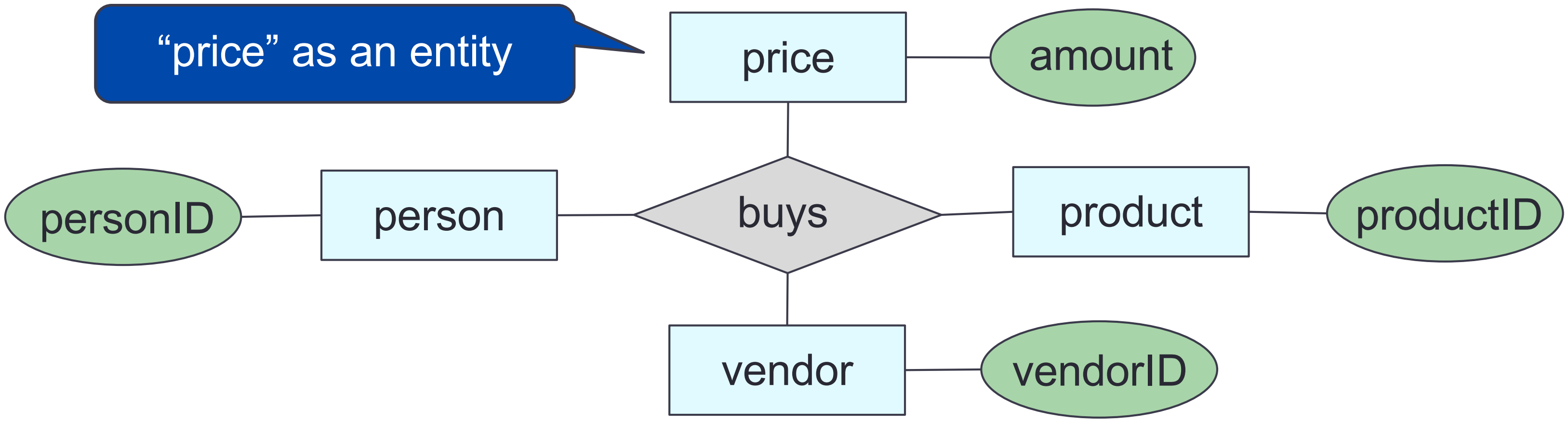
- Entities can model situations that attribute cannot model naturally
- Entities can participate in relationships
- Entities can have attributes
- Attributes cannot do any of these

Design Decision

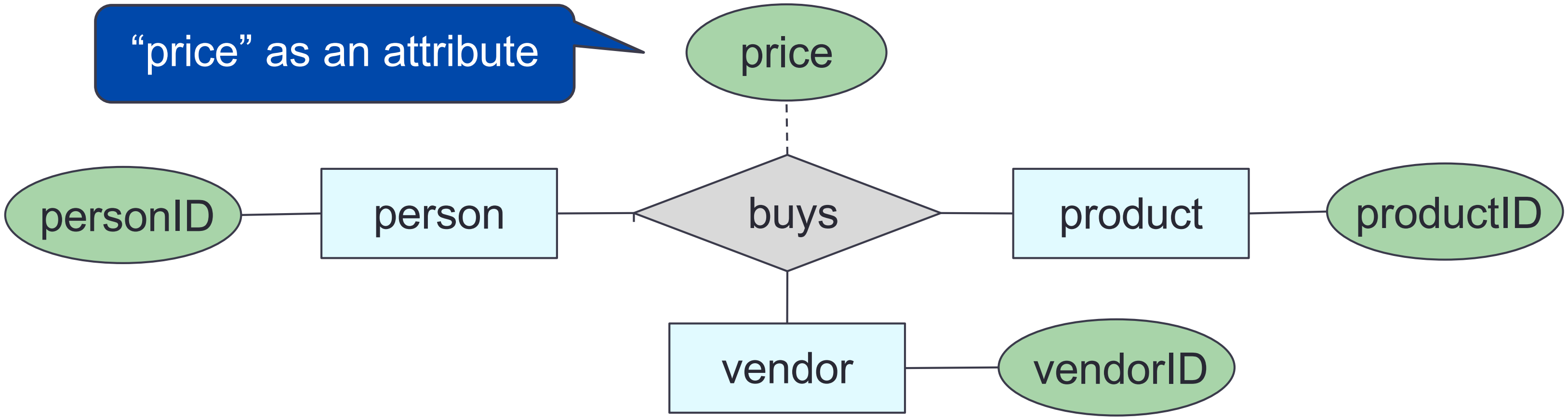
Should "price" be an entity or an attribute?



Design Decision (2)

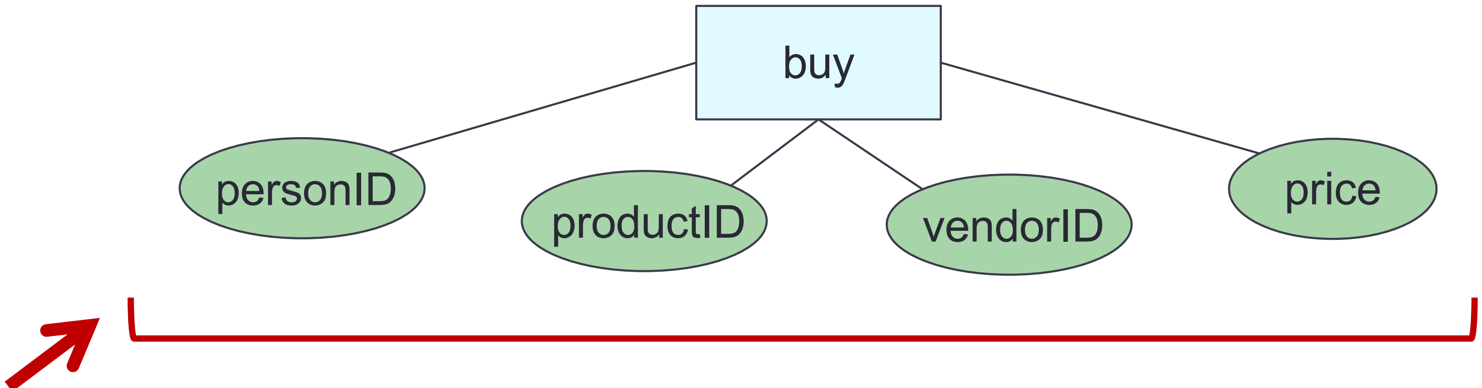


Since "price" is just the actual amount, treating it as an attribute is adequate. No need to make it an entity



Design Decision (3)

How about "buy" as an entity?



Should personID, productID, vendorID be entities or attributes?

- A "person" is an attribute of "buy"
- A "vendor" is an attribute of "buy"
- A "product" is an attribute of "buy"
- Cannot model something about a "person" (or "vendor" or "product") such as date-of-birth, address
- A "person" will involve in any relationship "buy" is associated with

Decisions to Make

- Entity set vs. attributes
  - Has more data → entity set
  - Is the data → attribute
- Entity set vs. relationship set
  - Entity set → nouns (students, faculty, loads, …)
  - Relationship → possession verbs (teaches, advises, owns, works for, …)
- Binary vs. n-ary relationship sets
- Specialization / generalization

Rules of Thumb

- Pick the right entities
- Keep it simple
- Don’t over complicate things
- Choose the right elements (entities vs. attributes)
- Choose the right relationships
- Follow the specification of the application to be built
- Avoid NULL value
- Avoid redundancy
- Consider small number of tables

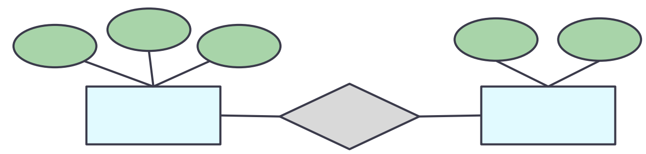
Database Design Process

revisit

Interact with users and domain experts to characterize the data

↓

Translate requirements into conceptual model (E-R diagrams)



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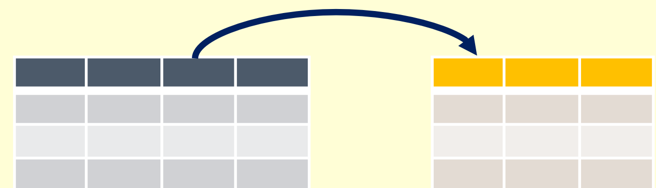
Convert the model to relational model (schema and constraints)



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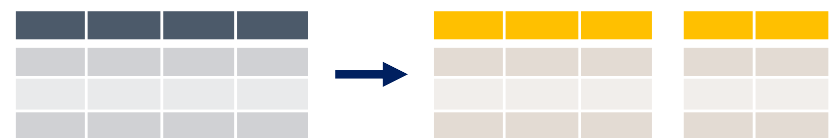
Normalize and develop conceptual (logical) schema of the database



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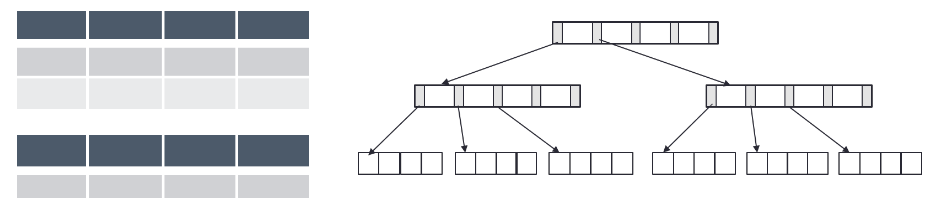
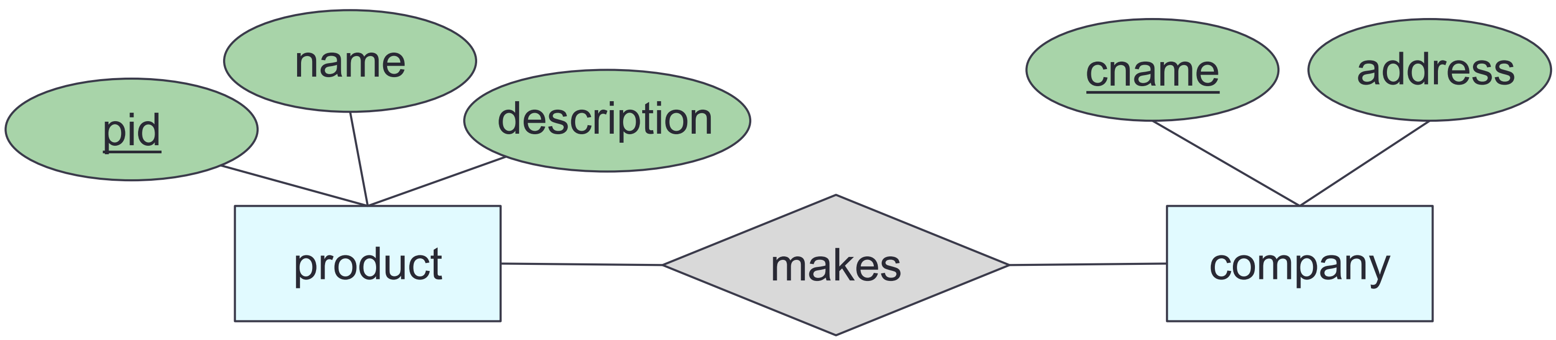
Develop physical schema (partitioning and indexing)



E-R Diagrams to Relations

There is a unique table which is assigned the name of the corresponding entity set or relationship set



product(pid, name, description)

company(cname, address)

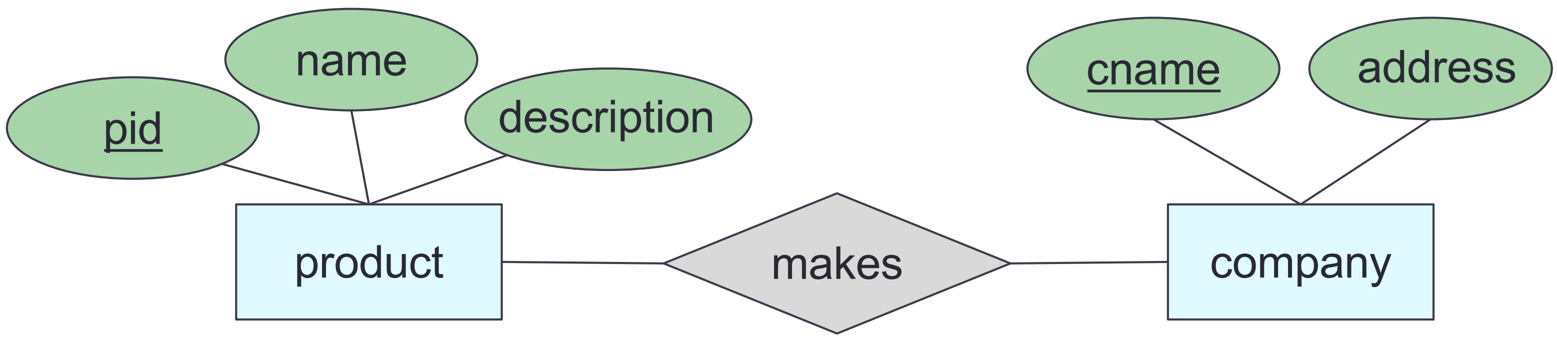
makes(cname, pid)

"Schema statement"

Strong Entity Set

Direct map:

- Entity name → relation name
- Attributes → columns
- Primary key: same as entity

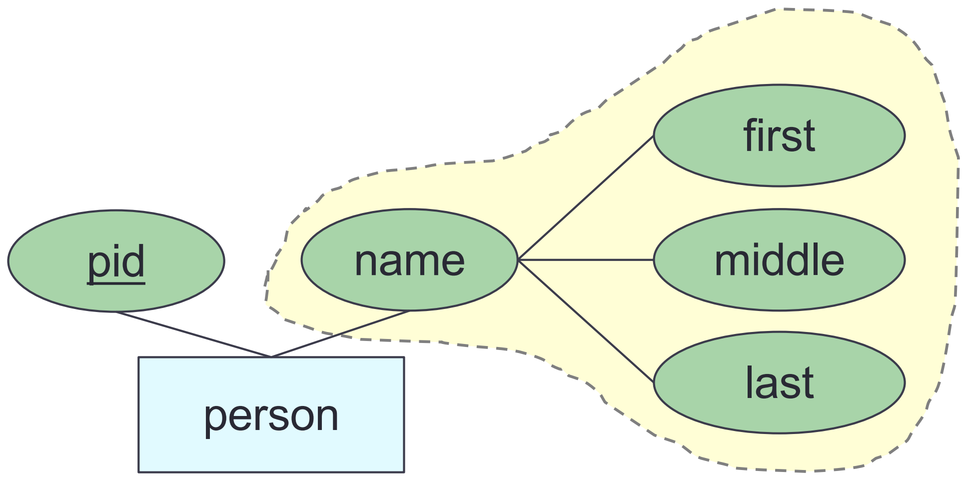


product(<u>pid</u>, name, description)
company(<u>cname</u>, address)
makes(<u>cname</u>, <u>pid</u>)

Strong Entity Set with Composite Attribute

Create separate attributes for each component

Don’t include the higher level attribute



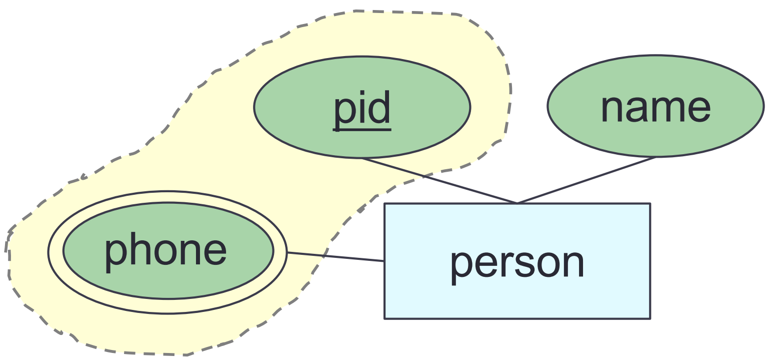
person(pid, first_name, middle_name, last_name)

Strong Entity Set with Multivalued Attribute

Create a separate table for the multivalued attribute

Name the table with the concatenation, separated by "_"
entityname_attributename

Primary key: all attributes

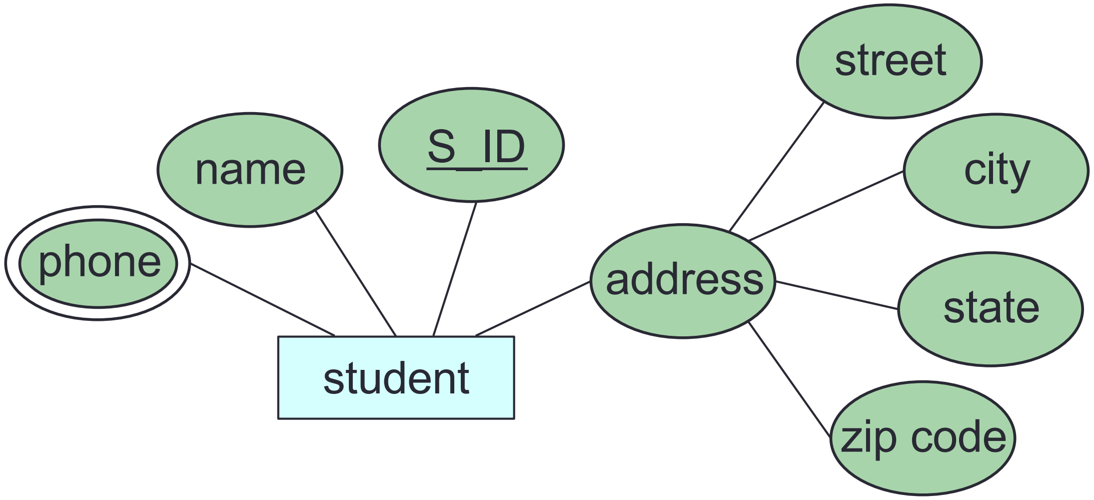


person(pid, name)

person_phone(pid, phone_number)

Let’s try: E-R to Relations (1)

Convert the following E-R diagram into relations



student (S_ID, name, street, city, state, zip code)
student_phone (S_ID, phone)

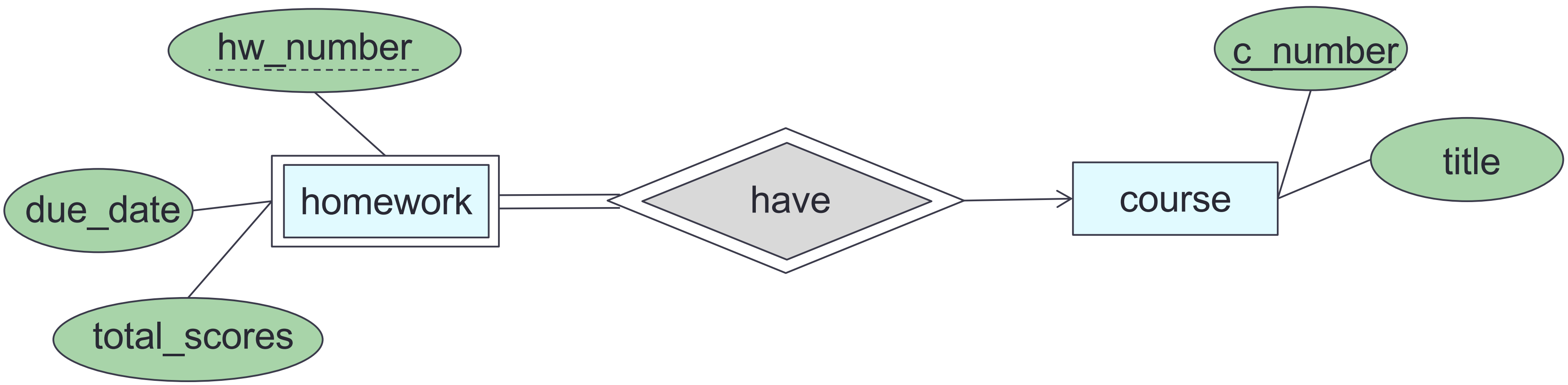
PK of this table is a combination of all attributes

Weak Entity Set

Let *A* be a weak entity set and *B* be the identifying strong entity set on which *A* depends

Create a table with primary key of *B* and all *A*'s attributes

Primary key: primary key of *B* (strong entity) and discriminator of *A*

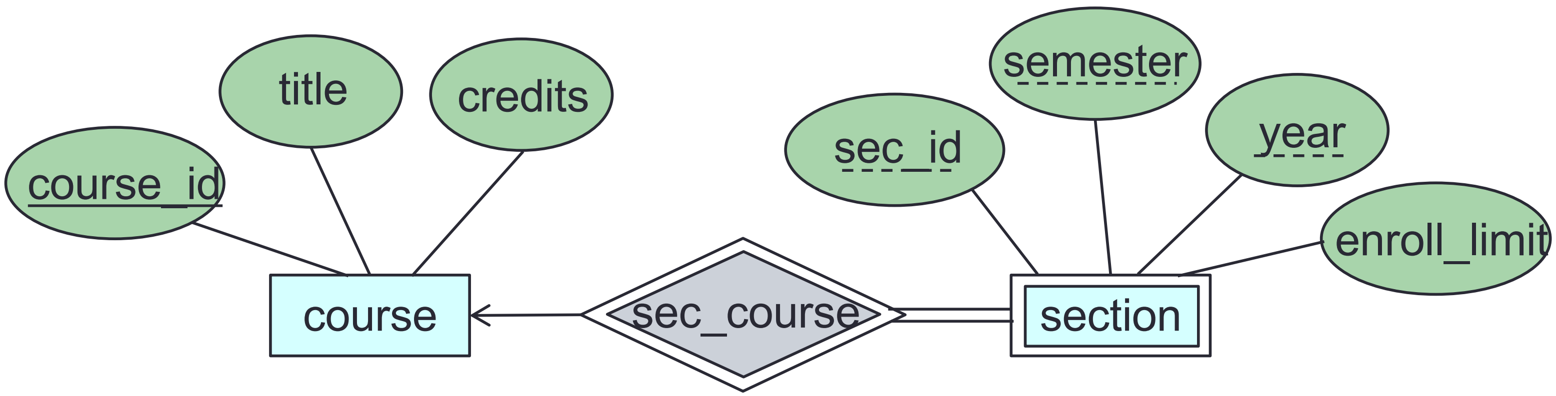


course(<u>c_number</u>, title)

homework(<u>c_number</u>, <u>hw_number</u>, due_date, total_scores)

Let’s try: E-R to Relations (2)

Convert the following E-R diagram into relations

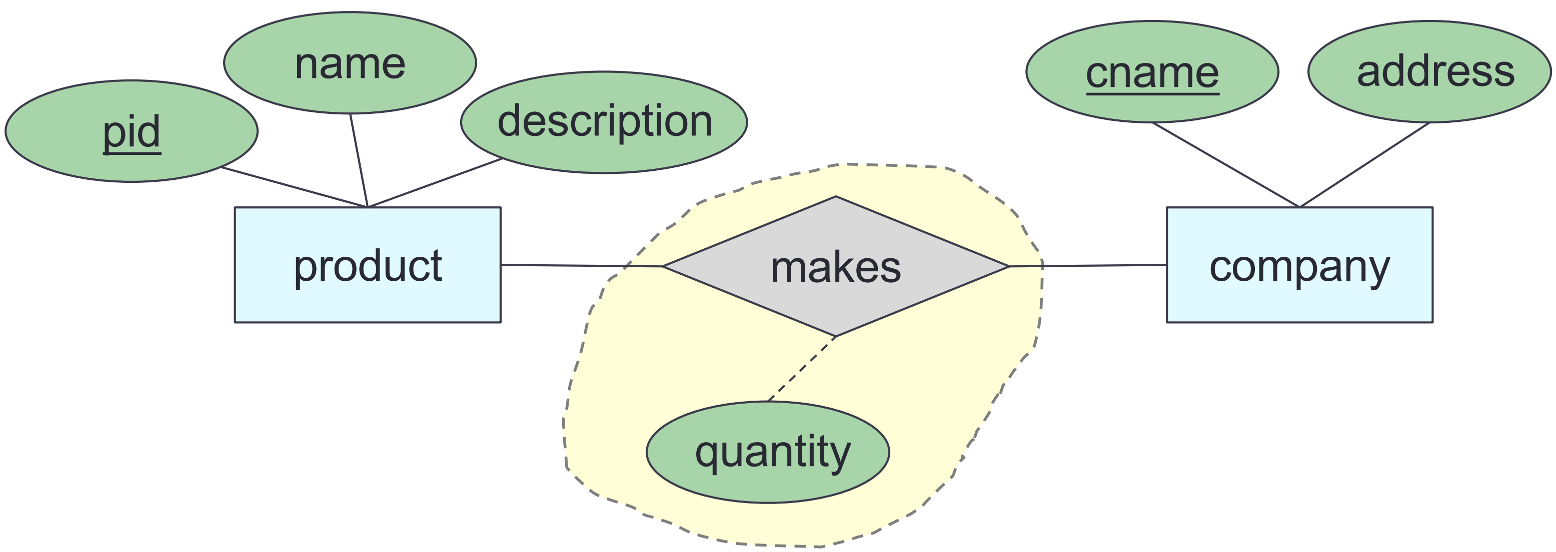


course (<u>course_id</u>, title, credits)
section (<u>course_id</u>, <u>sec_id</u>, <u>semester</u>, <u>year</u>, enroll_limit)

Relationship Set: Many-to-Many

Table: primary keys of both participating entity sets and any attributes on the relationship itself

Primary key: primary keys of both participating entity sets

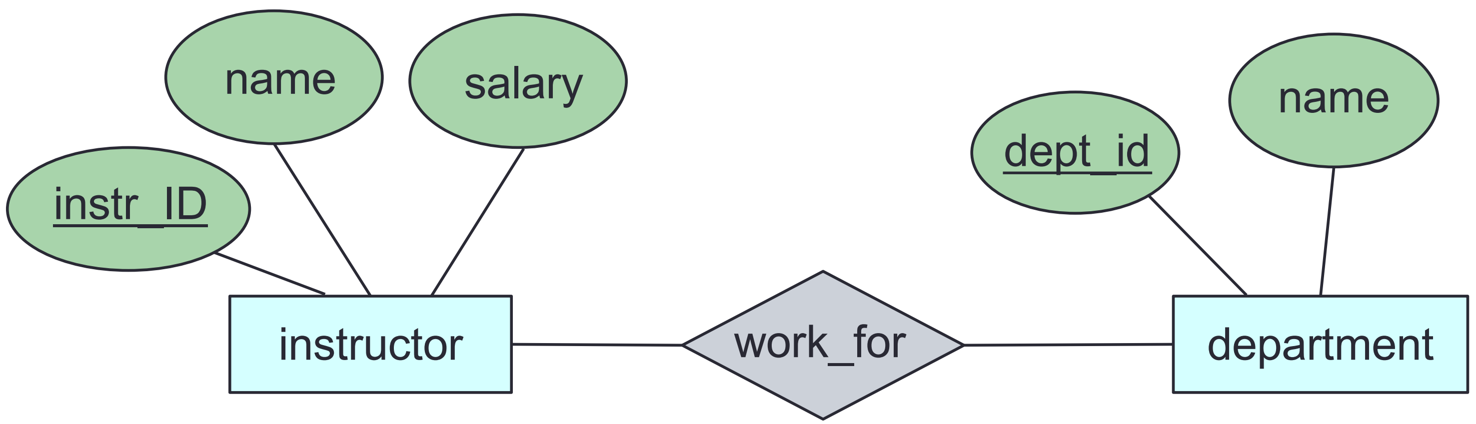


product(pid, name, description)
company(cname, address)
makes(pid, cname, quantity)

Primary keys of both entities

Let’s try: E-R to Relations (3)

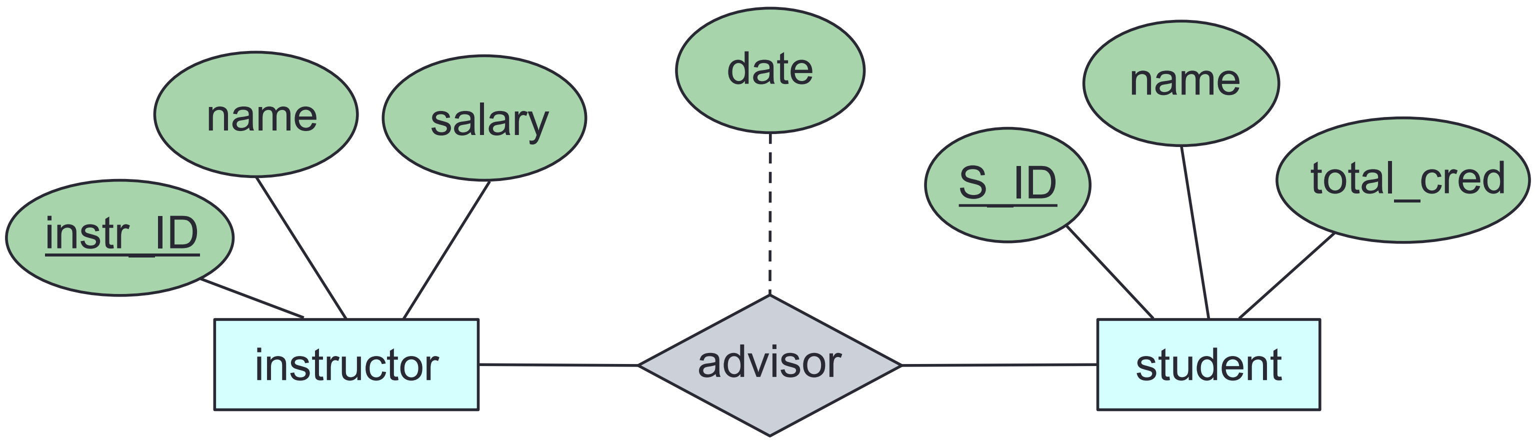
Convert the following E-R diagram into relations



instructor (instr_ID, name, salary)
department (dept_id, name)
work_for (instr_ID, dept_id)

Let’s try: E-R to Relations (4)

Convert the following E-R diagram into relations

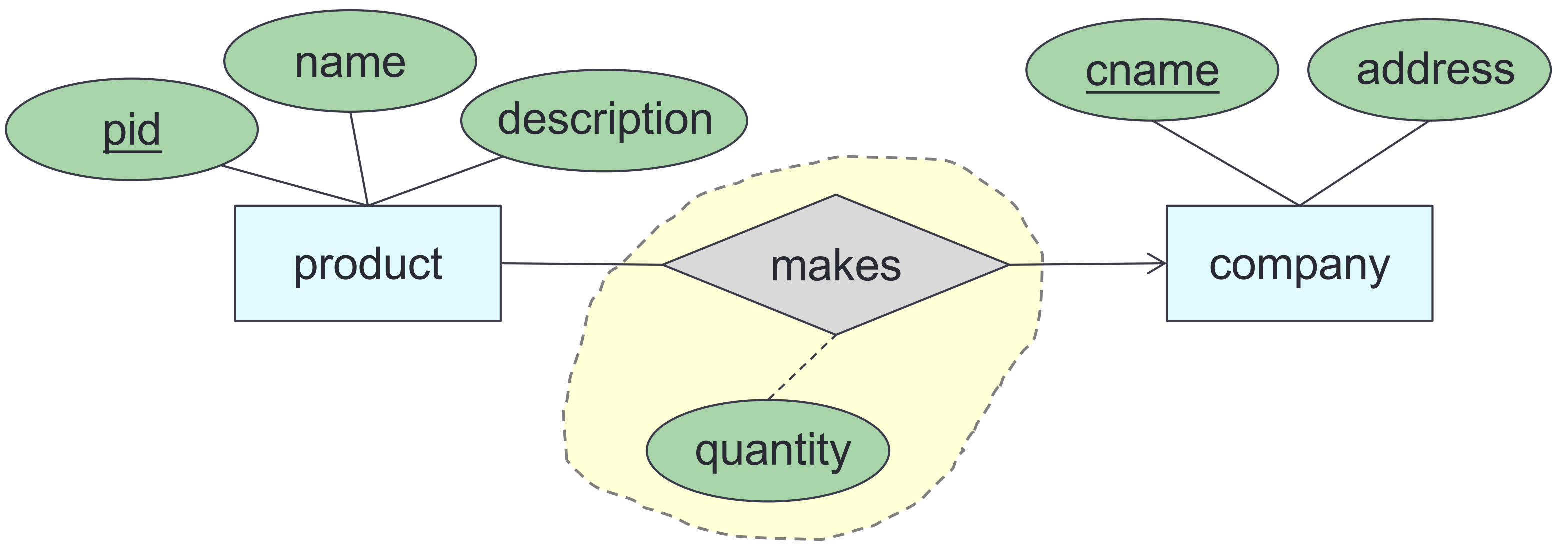


instructor (<u>instr_ID</u>, name, salary)
student (<u>S_ID</u>, name, total_cred)
advisor (<u>instr_ID</u>, <u>S_ID</u>, date)

Relationship Set: Many-to-One / One-to-Many

Table: primary keys of both participating entity sets and any attributes on the relationship itself

Primary key: primary keys of the entity set on the "many" side



product(pid, name, description)

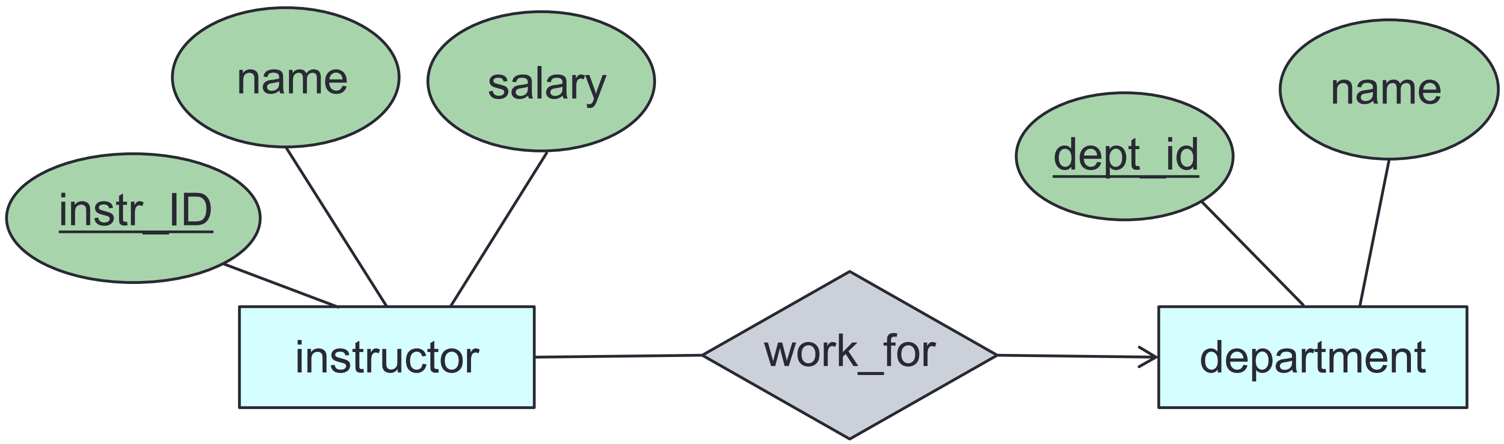
company(cname, address)

makes(pid, cname, quantity)

Primary key of the "many" side

Let's try: E-R to Relations (5)

Convert the following E-R diagram into relations

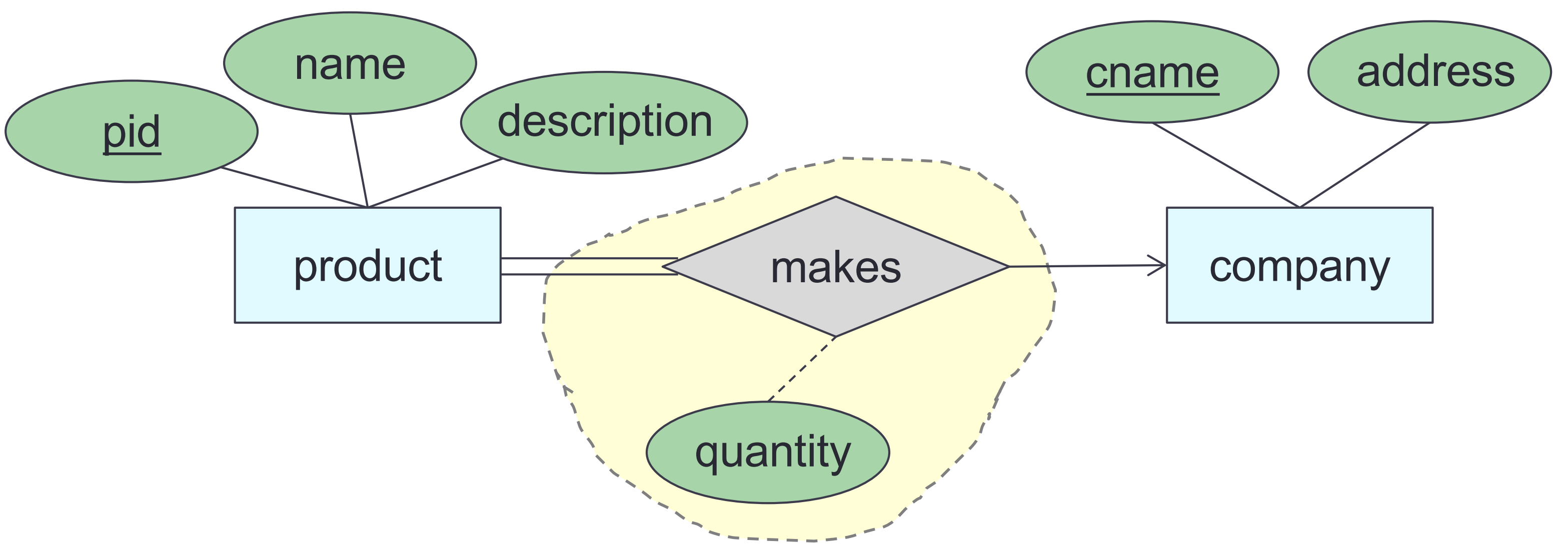


instructor (<u>instr_ID</u>, name, salary)
department (<u>dept_id</u>, name)
work_for (<u>instr_ID</u>, dept_id)

Relationship Set: Total Participation

Because the total participation requires all entity to be participated in the relationship

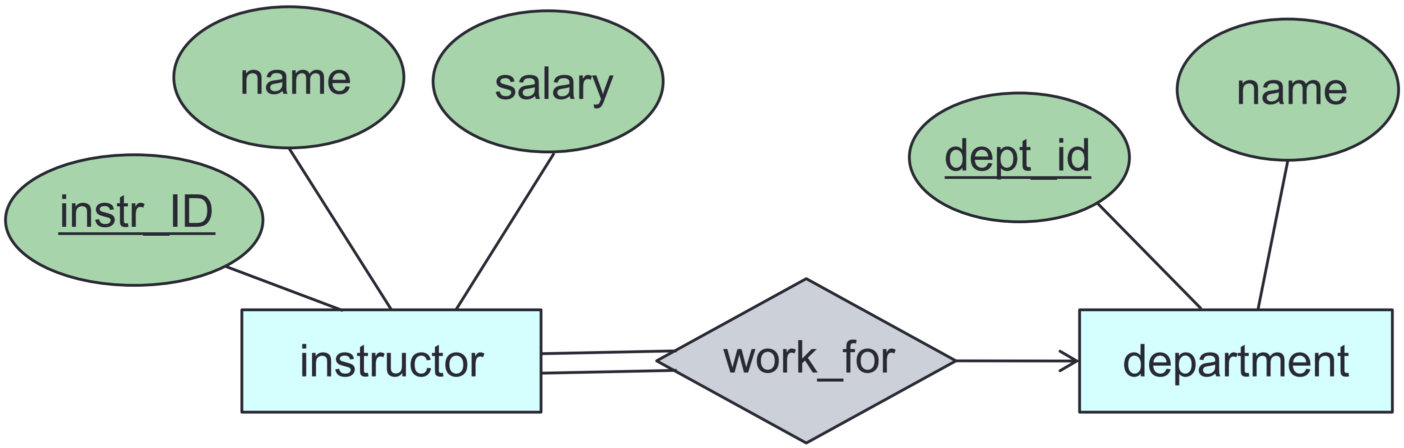
→ add the primary key of the "one" side to the "many" side entity set, no table for relationship needed



product(<u>pid</u>, name, description, cname, quantity)
company(<u>cname</u>, address)

Let's try: E-R to Relations (6)

Convert the following E-R diagram into relations



instructor (<u>instr_ID</u>, name, salary, dept_id)
department (<u>dept_id</u>, name)

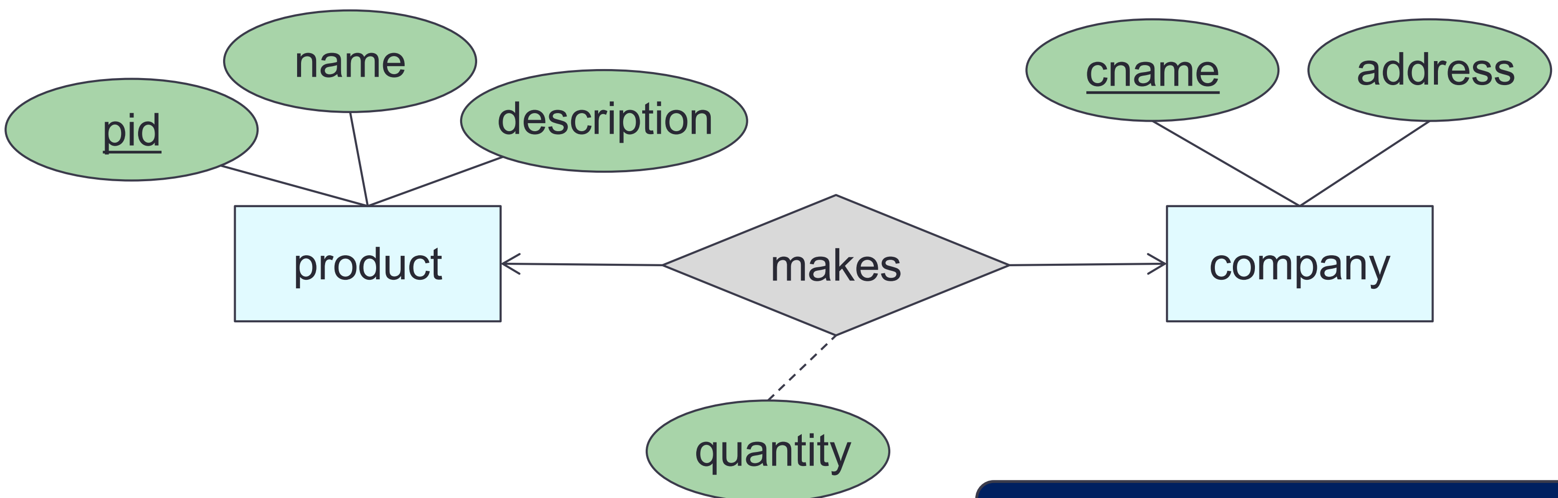
Relationship Set: One-to-One

Table: Either side can be used as the main table

(Which side? doesn't matter. Pick the one that makes the most sense)

Add the other side's primary key to it

Primary key: primary keys of the entity set you pick

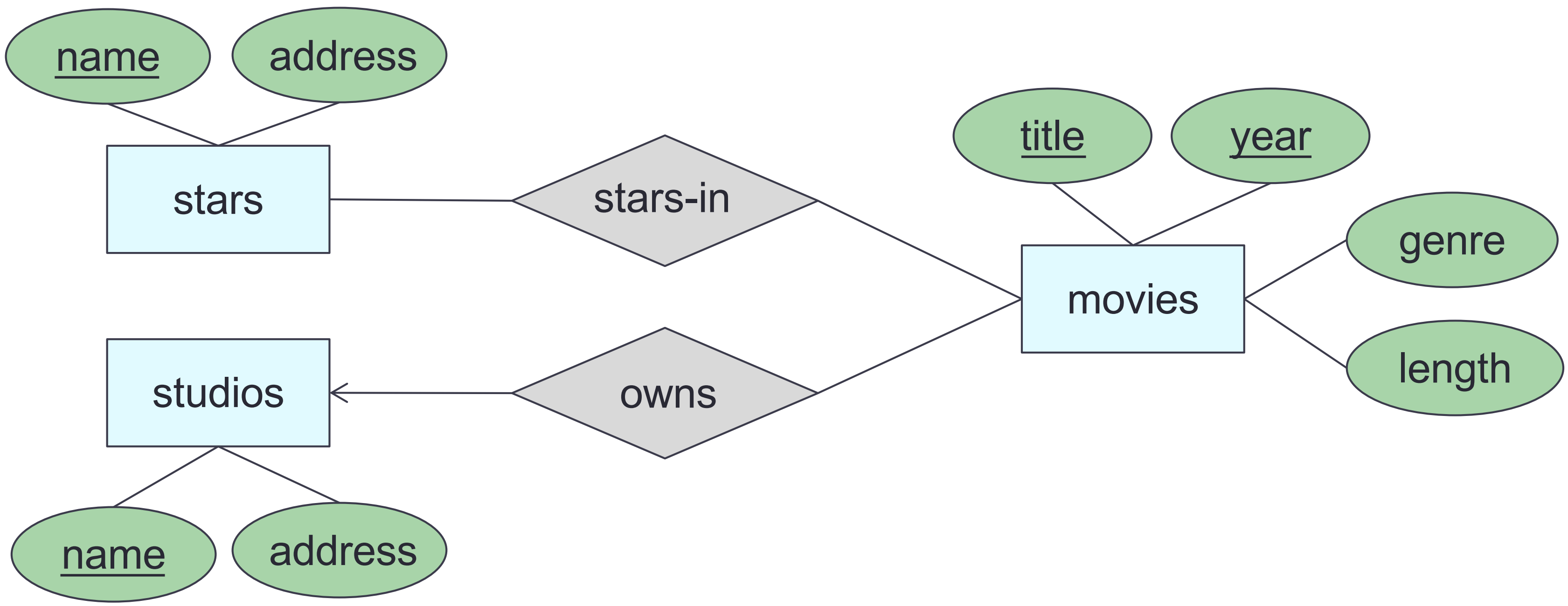


product(pid, name, description)
company(cname, address, pid, quantity)

Primary key of the chosen entity

Let's try: E-R to Relations (7)

Convert the following E-R diagram into relations



stars(name, address)

stars-in(title, year, starsName)

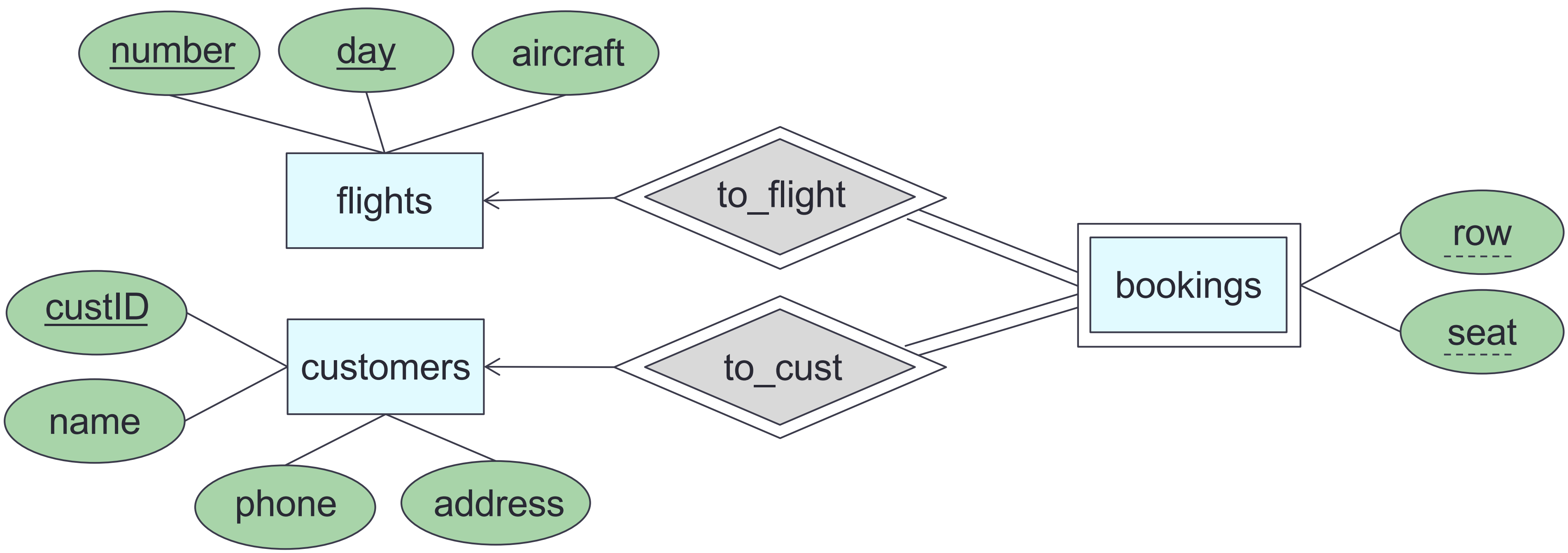
studios(name, address)

owns(title, year, studioName)

movies(title, year, genre, length)

Let's try: E-R to Relations (8)

Convert the following E-R diagram into relations

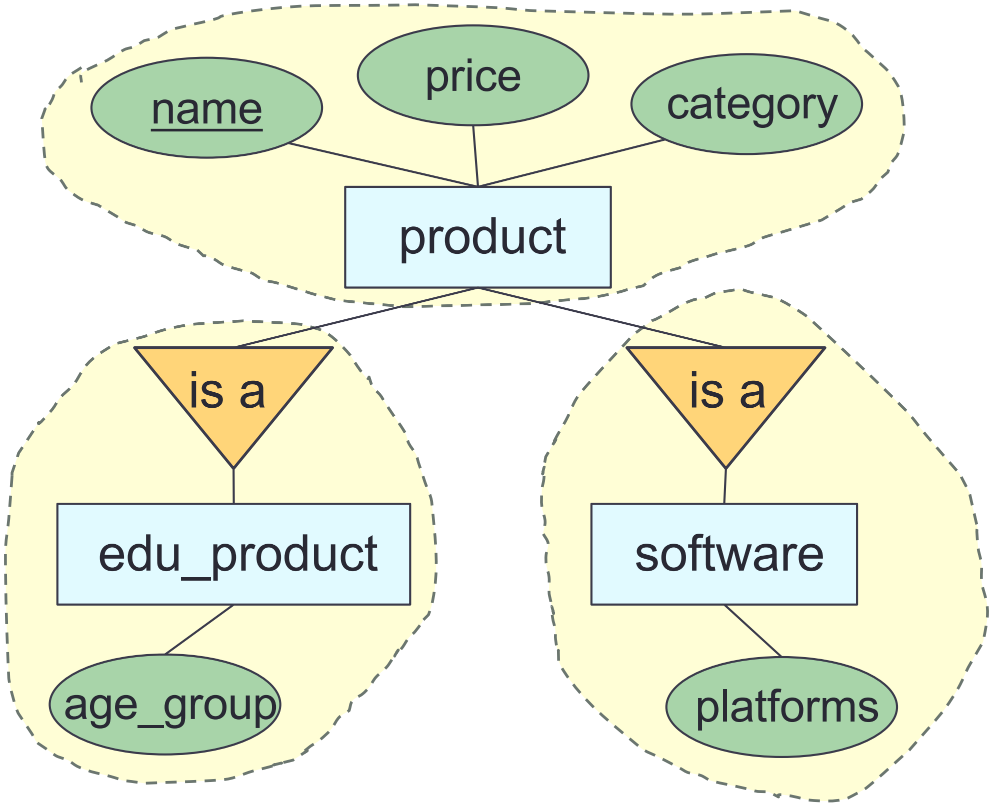


flights(<u>number</u>, <u>day</u>, aircraft)

customer(<u>custID</u>, name, phone, address)

bookings(<u>number</u>, <u>day</u>, <u>custID</u>, <u>row</u>, <u>seat</u>)

Subclass (Option 1)



Keep everything

Primary key of the lower level entity set: from the higher level

Drawback: need to access more tables to get info about the lower levels

product(name, price, category)

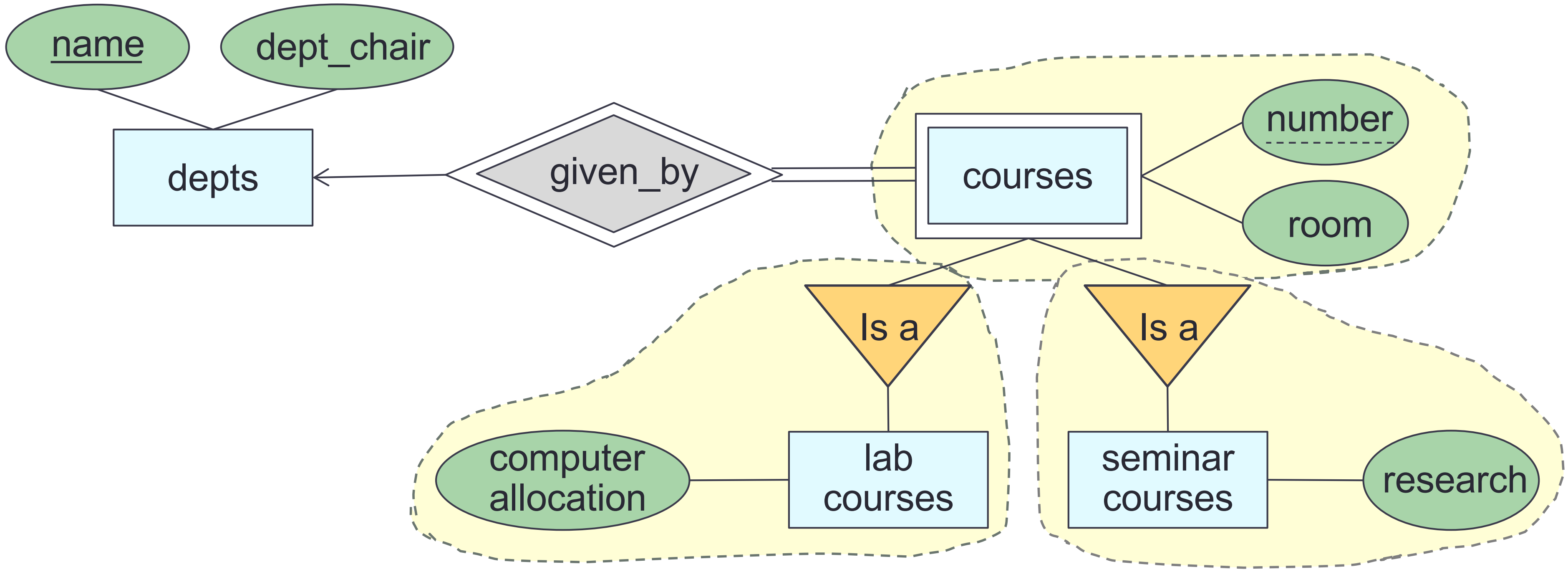
edu_product(name, age_group)

software(name, platforms)

Keep everything

Let's try: Subclasses (option 1)

Convert the following E-R diagram into relations



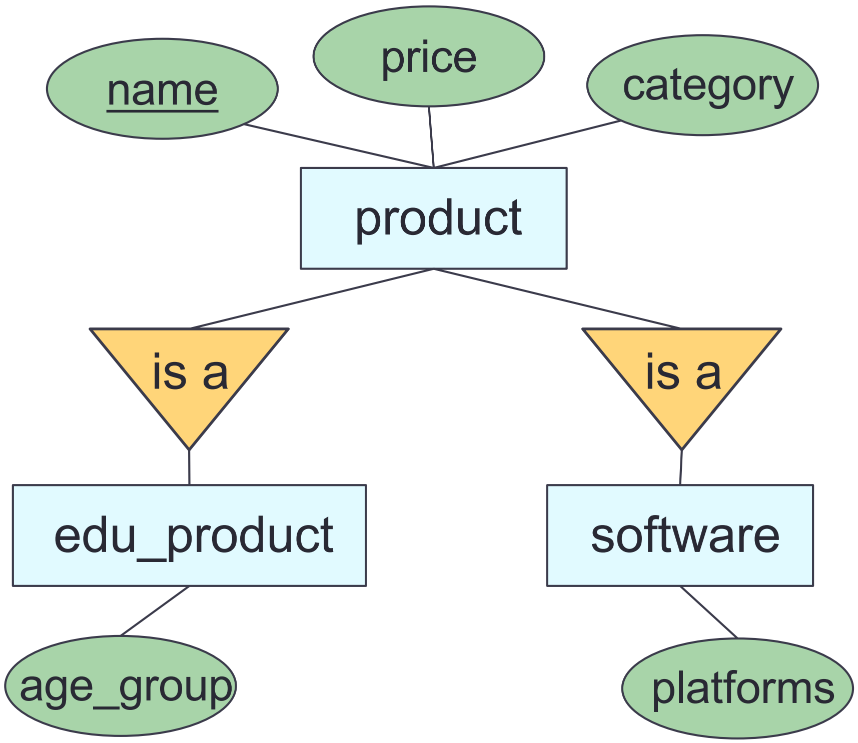
depts(<u>name</u>, dept_chair)

courses(<u>deptName</u>, <u>number</u>, room)

labCourses(<u>deptName</u>, <u>number</u>, computerAllocation)

seminarCourses(<u>deptName</u>, <u>number</u>, research)

Subclass (Option 2)



Keep specialization entity sets

No table for generalization entity set

Primary key of the lower level entity set: from the higher level

Drawback: redundancy if entities have more than one specialization

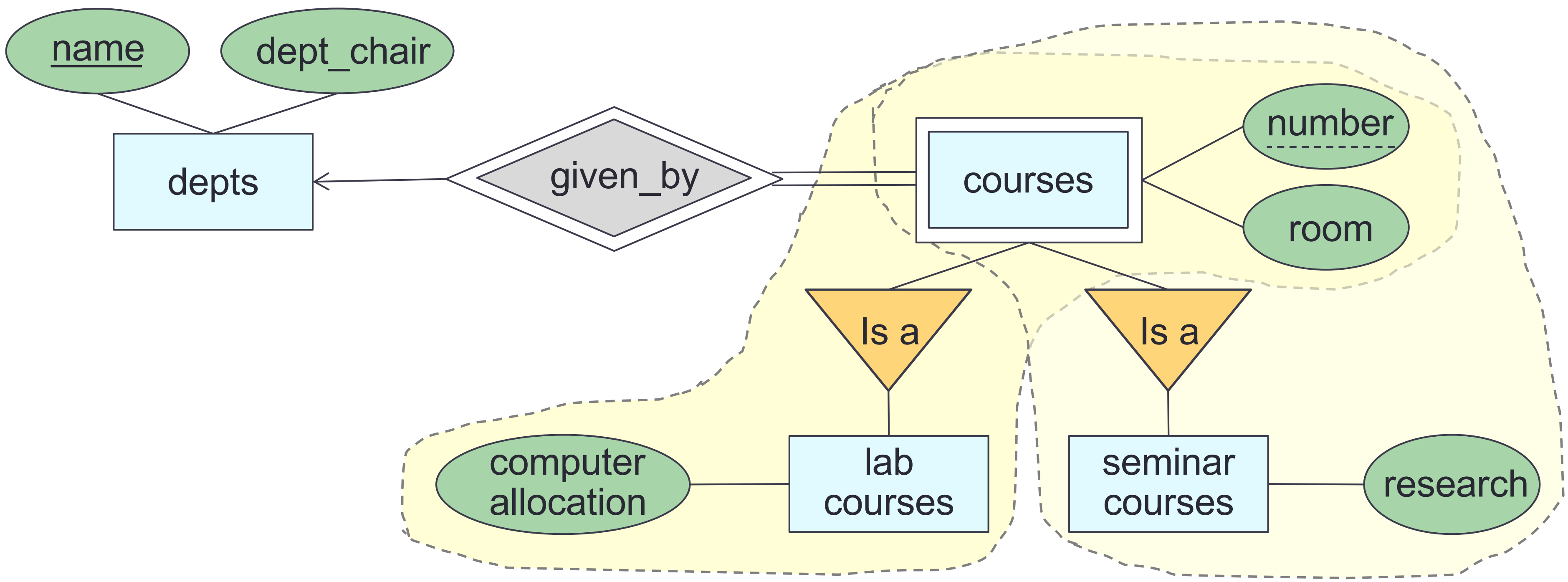
edu_product(<u>name</u>, price, category, age_group)

software(<u>name</u>, price, category, platforms)

Push down

Let’s try: Subclasses (option 2)

Convert the following E-R diagram into relations

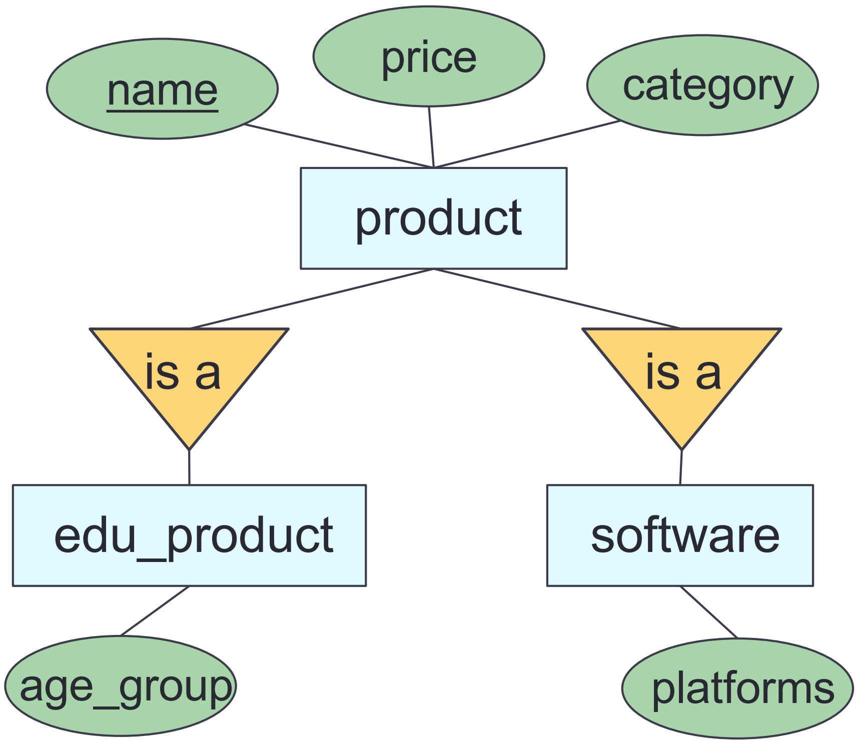


depts(<u>name</u>, dept_chair)

labCourses(<u>deptName</u>, <u>number</u>, room, computerAllocation)

seminarCourses(<u>deptName</u>, <u>number</u>, room, research)

Subclass (Option 3)



Keep generalization entity set

No table for specialization entity sets

Drawback: NULL in attributes from specialization entity sets

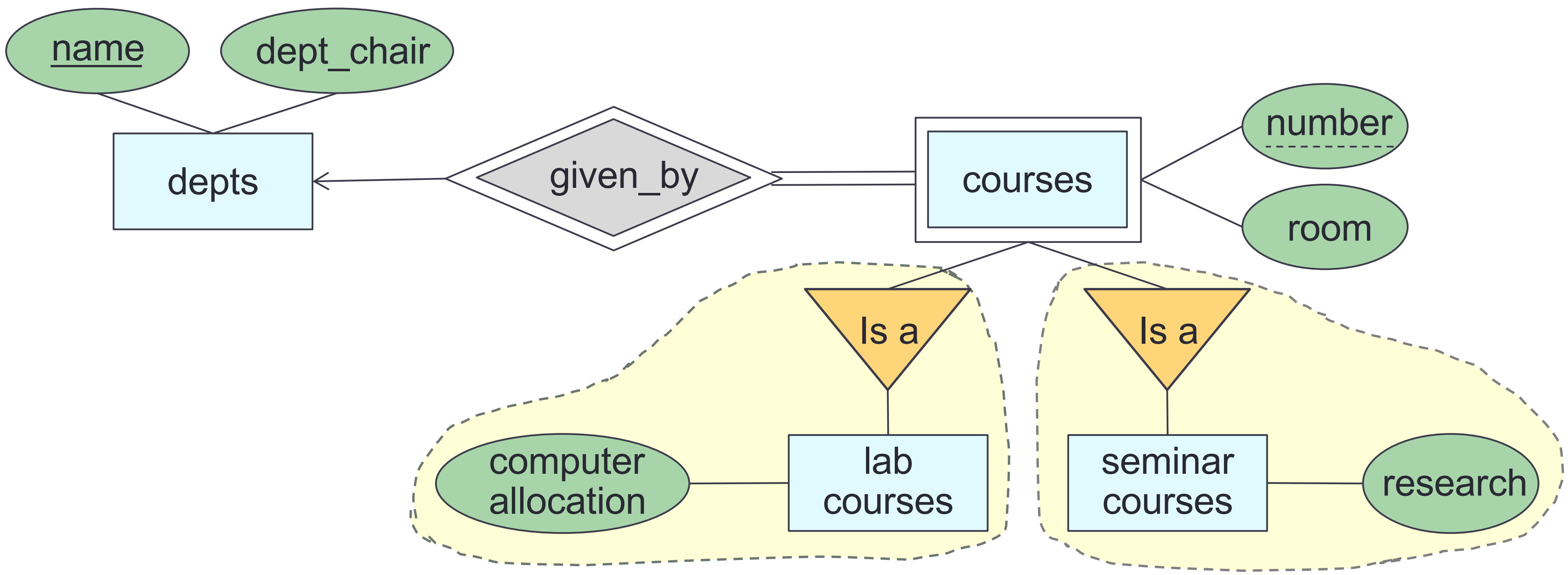
Although less duplication of data, need to handle NULL value

Push up

product(name, price, category, age_group, platforms)

Let's try: Subclasses (option 3)

Convert the following E-R diagram into relations



depts(<u>name</u>, dept_chair)

courses(<u>deptName</u>, <u>number</u>, room, computerAllocation, research)

Subclass: Design Decision

Depending on the number of attributes of the generalization entity set and specialization entity set

- If balanced → do option 1 (create all)
- If more attributes in specialization → do option 2
- If more attributes in generalization → do option 3

In general, design decision depends on

- The number of attributes
- DB administrator's decision

Overall goal: minimize duplication
(there is no one correct way)

Wrap-Up

- Roles in Relationships
- Relationships: binary, n-ary
- Weak entity
- Subclasses
- Converting from E-R diagrams to relational designs
  - Turn each entity set into a relation with the the same set of attributes
  - Replace a relationship by a relation whose attributes are the keys for the connected entity sets
  - Weak entity sets cannot be translated straightforwardly to relations
  - "Is a" relationships and subclasses require careful treatment

What's next?

- Apply the concept to database scenarios and fine-tuning database structure