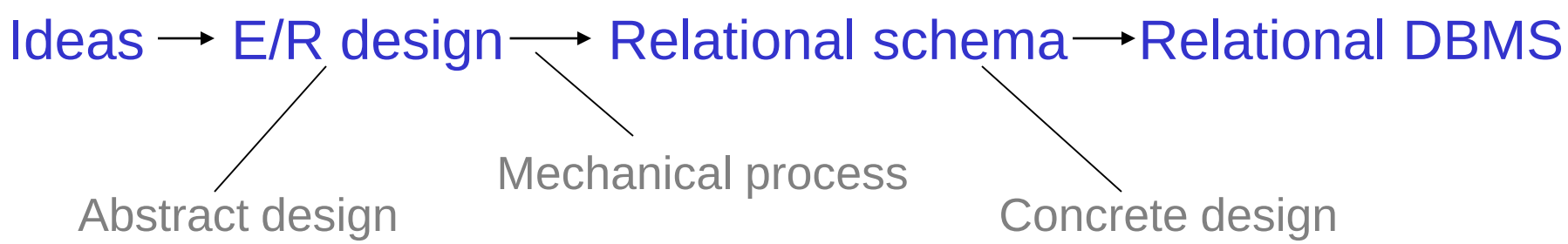
Entity-Relationship Model

Database Design

- Designing a database:
  - what information the database must hold, and
  - what relationships are there among components of that information.

- Notation for expressing designs: Entity-Relationship (E/R) model



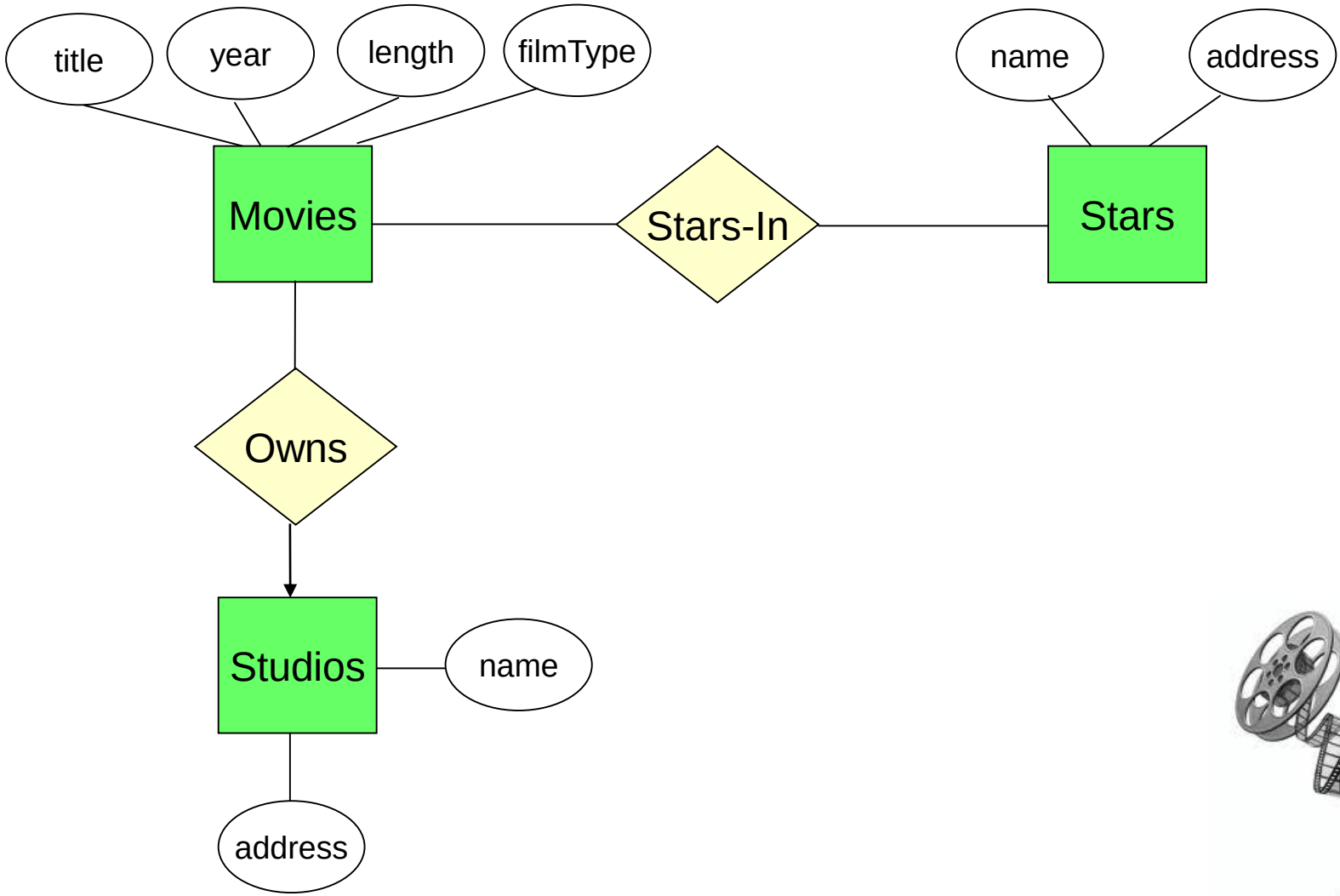
Elements of the E/R Model

Entity sets

Attributes

Relationships

Example

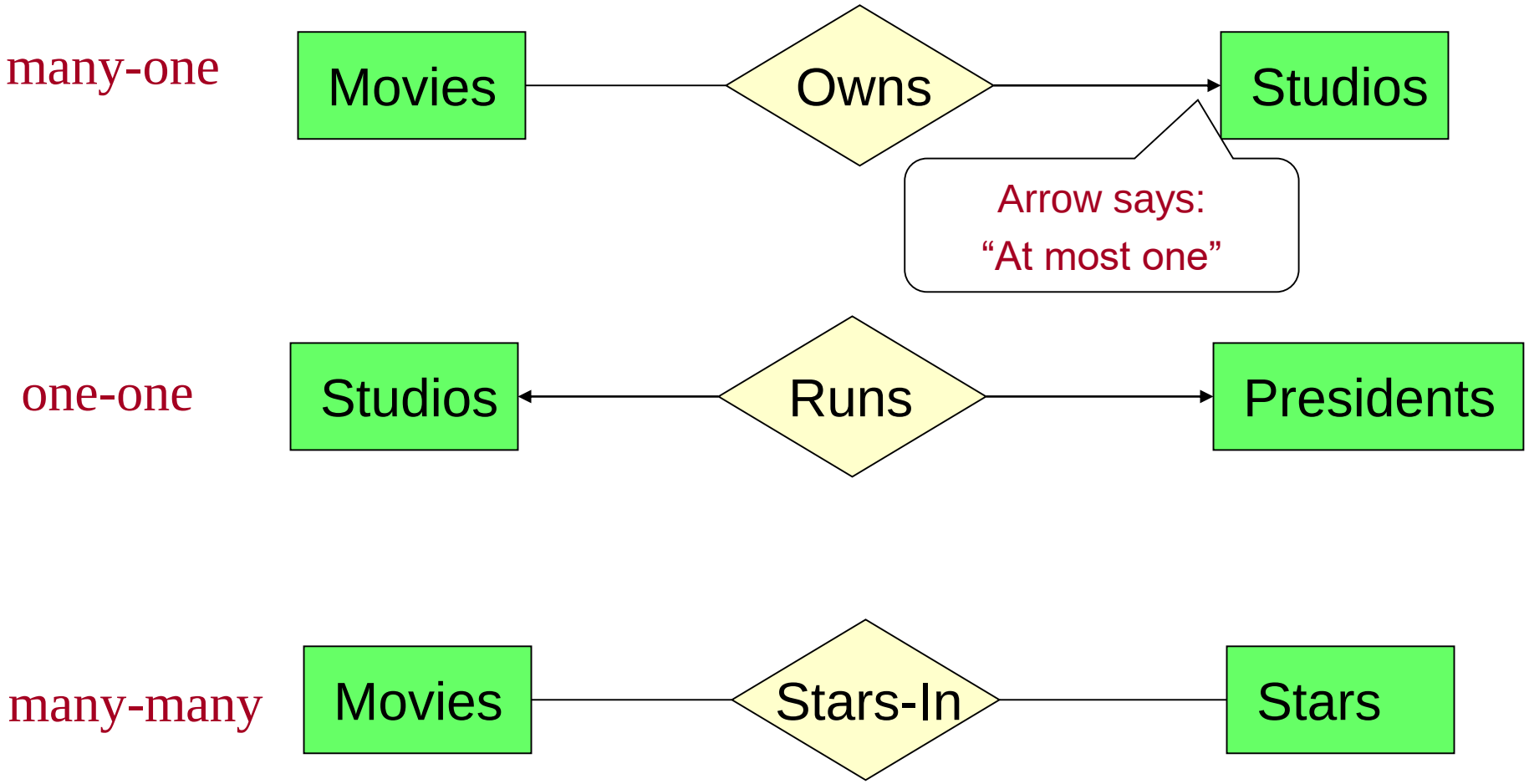

title
year
length
filmType
name
address
Movies
Stars-In
Stars
Owns
Studios
name
address

Visualizing Binary E/R Relationships

They are just sets of pairs

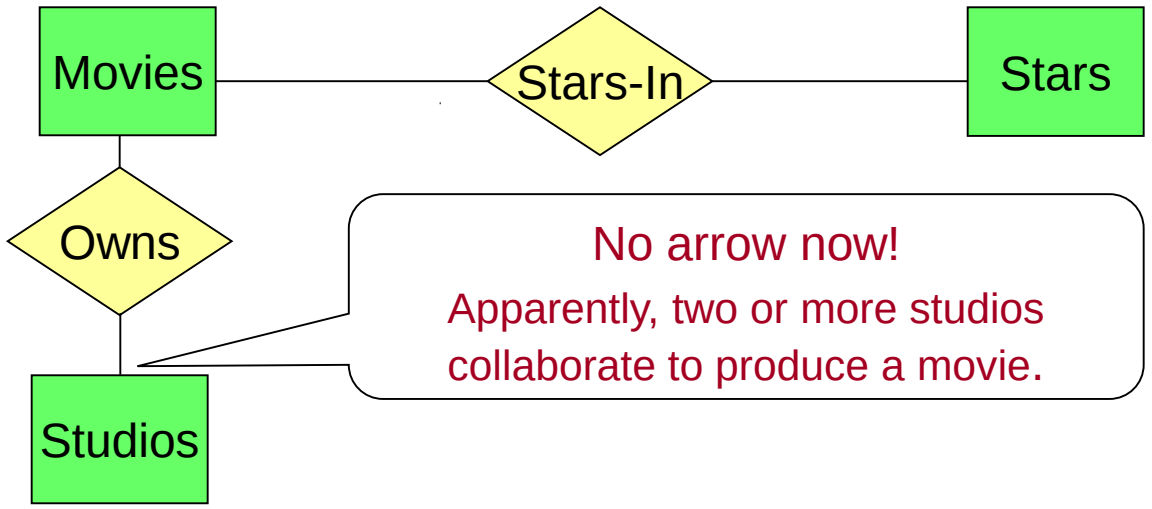
Movies	Stars
Basic Instinct	Sharon Stone.
Total Recall	Arnold Schwarzenegger.
Total Recall	Sharon Stone.

Multiplicity of Relationships



Sometimes binary relationships aren't enough!

Example



What could go wrong with this design?

Problem with finding which stars a studio is paying for a given movie.

Why some studio-movie-star triples can be invalid?

E.g.

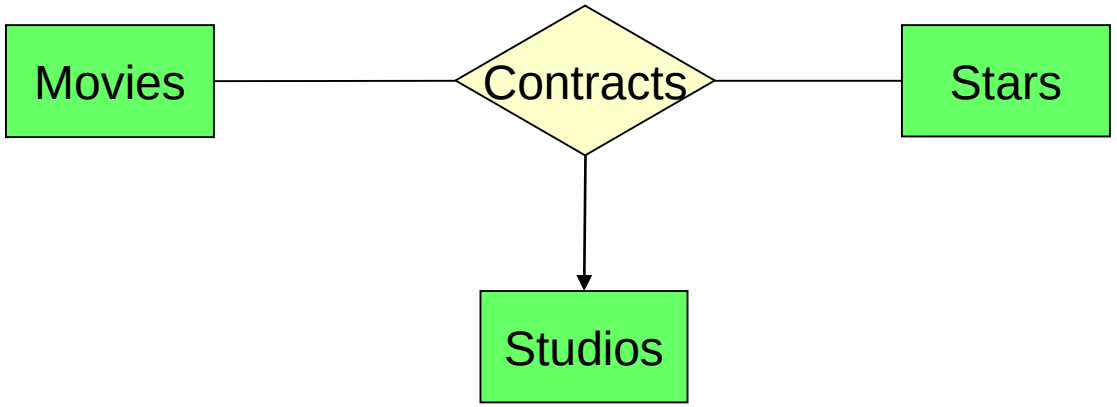
- Carolco Pictures paid Arnold Schwarzenegger for Total Recall
  TriStar paid Sharon Stone for Total Recall.

- Using “Owns” and “Stars-In” we will have the following triples:
  (CP, TR, AS) (CP, TR, SS) (TS, TR, AS) (TS, TR, SS)

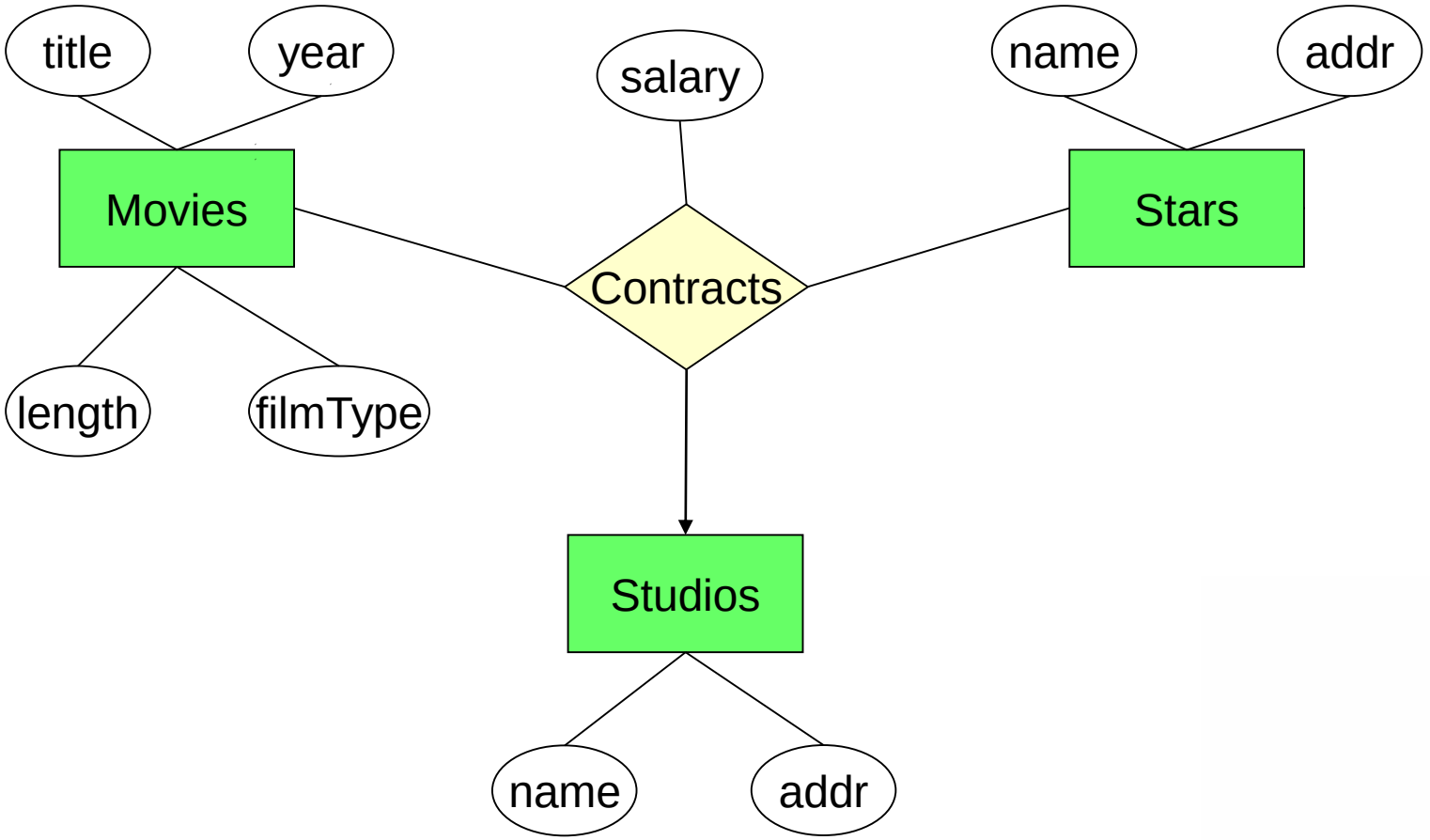
- The second and the third triples aren’t valid.

- If we consider the collection of all the valid triples, it is nothing else but a **three way relationship** between **Studios**, **Movies** and **Stars**

Solution: Three-way relationship

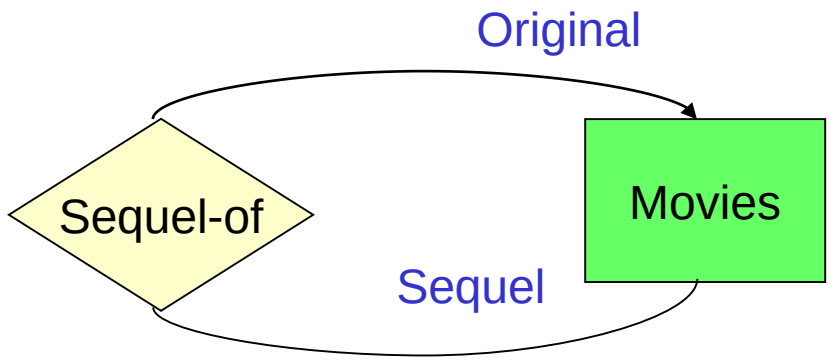


Attributes on Relationships



Roles in a relationship

- An entity set can appear two or more times in a relationship.
- Each line to the entity set represents a different role.

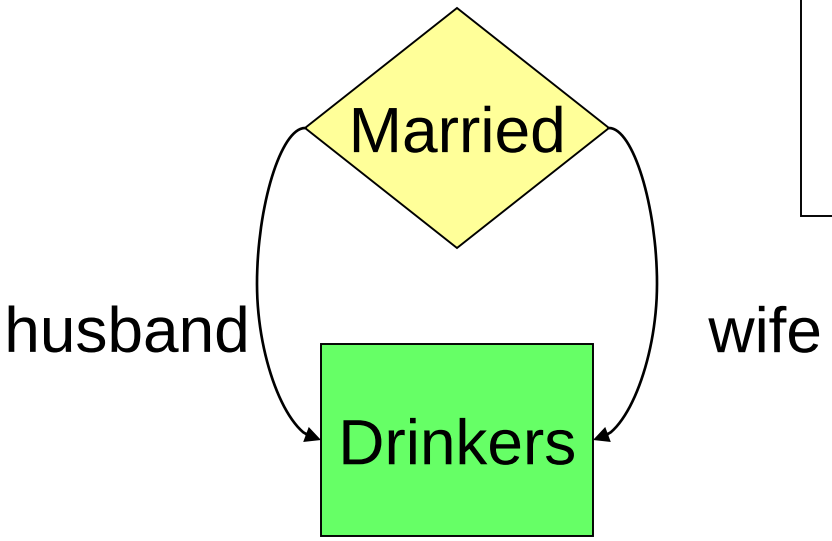


- A movie may have many sequels, but for each sequel there is only one original movie.

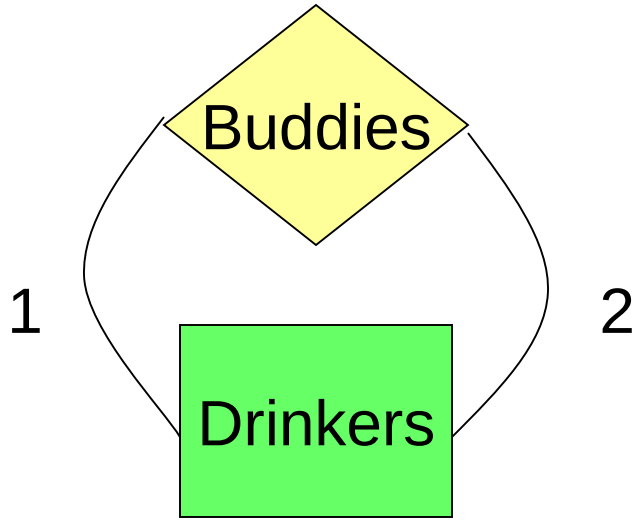
Another Example

Relationship Set

Husband	Wife
Bob	Ann
Joe	Sue
…	…



Another Example



Relationship Set

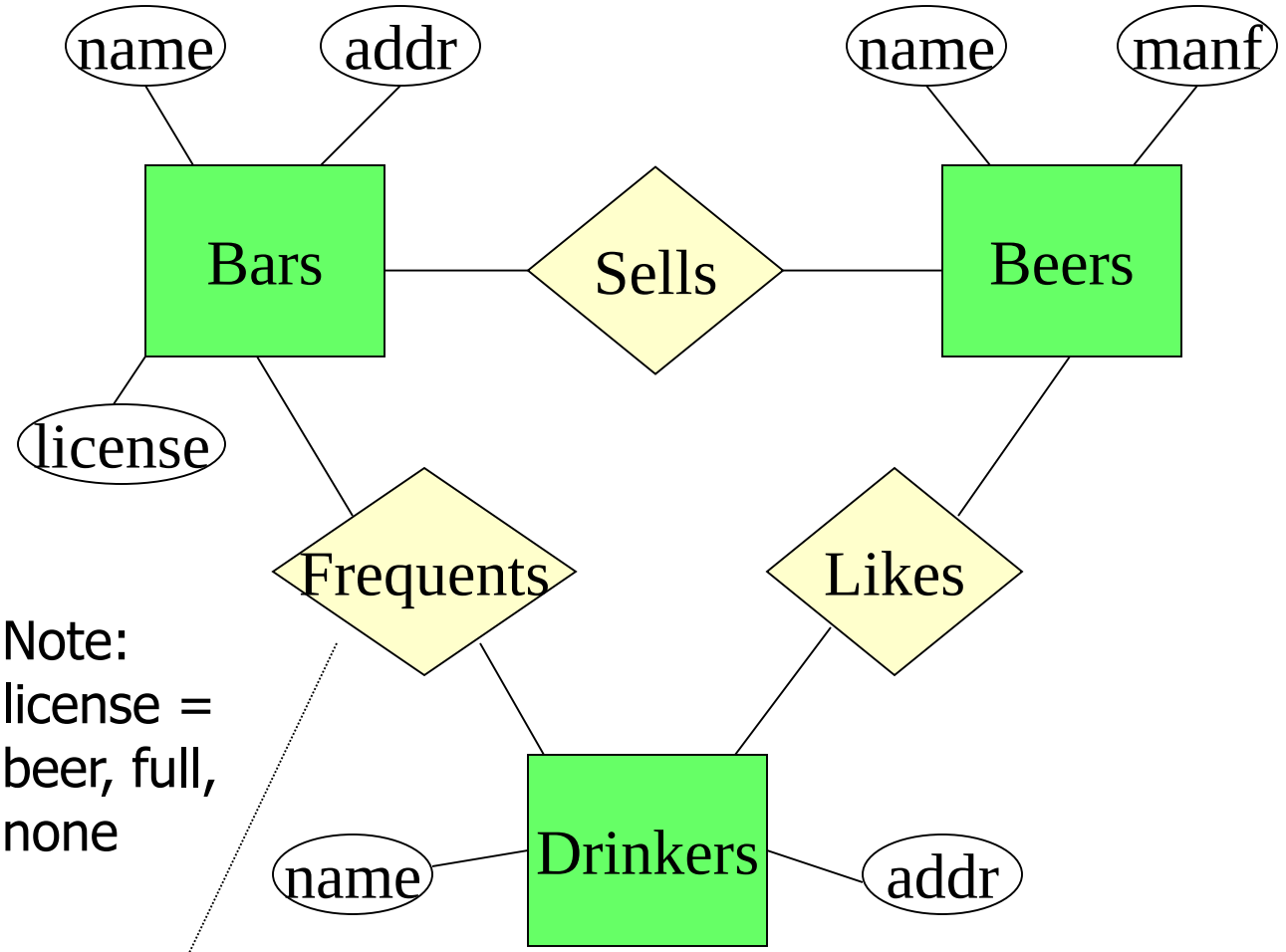
Buddy1	Buddy2
Bob	Ann
Joe	Sue
Ann	Bob
Joe	Moe
…	…

“Bars-Beer-Drinkers” (BBD) Example

- Bars sell some beers.
- Drinkers like some beers.
- Drinkers frequent some bars.

- What would the E/R diagram be?

"Bars-Beer-Drinkers" (BBD) Example



Note:
license =
beer, full,
none

Why we need it?

Bars sell some beers.

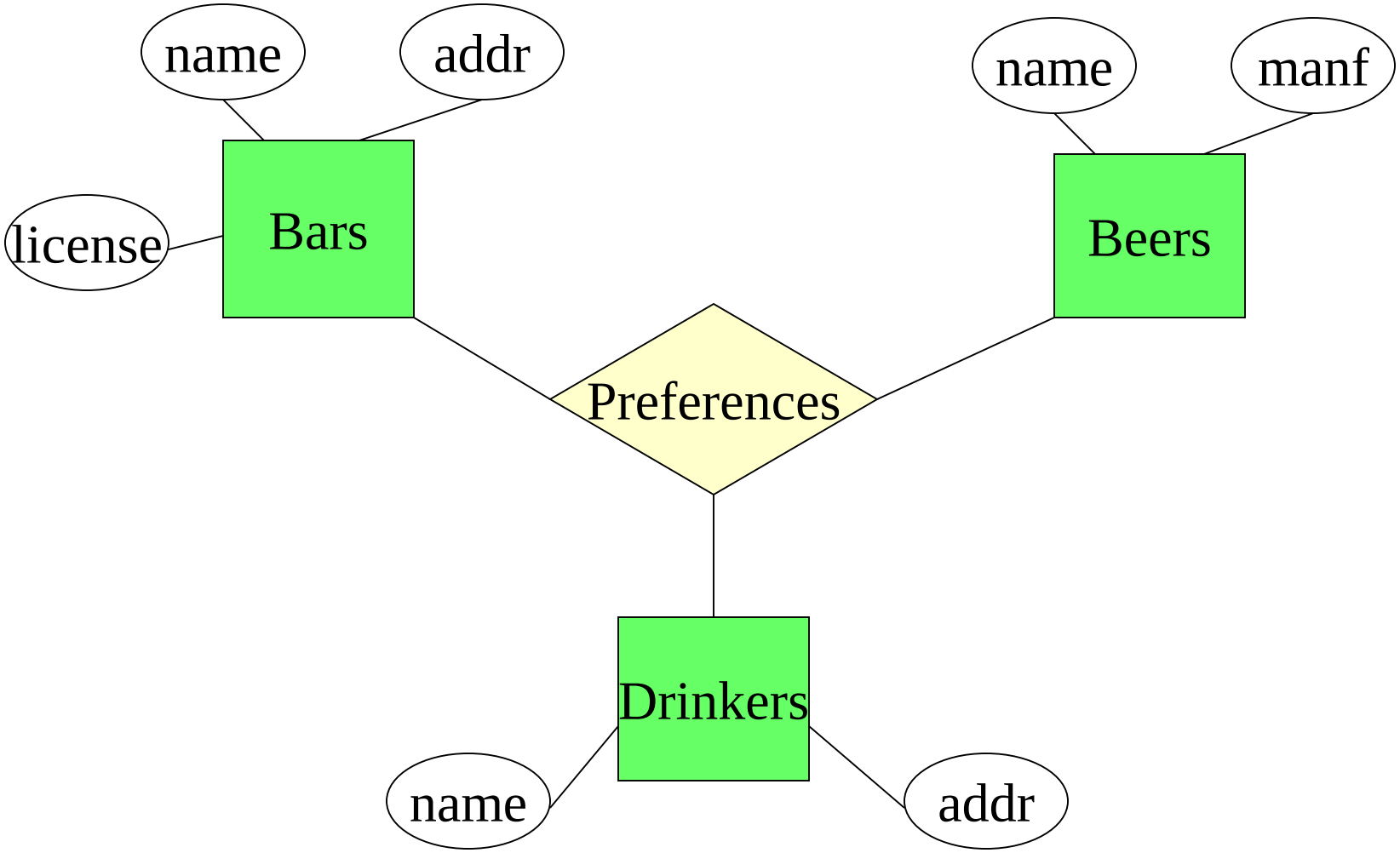
Drinkers like some beers.

Drinkers frequent some bars.

BBD Multiway Relationship

- Suppose that drinkers will only drink certain beers at certain bars.

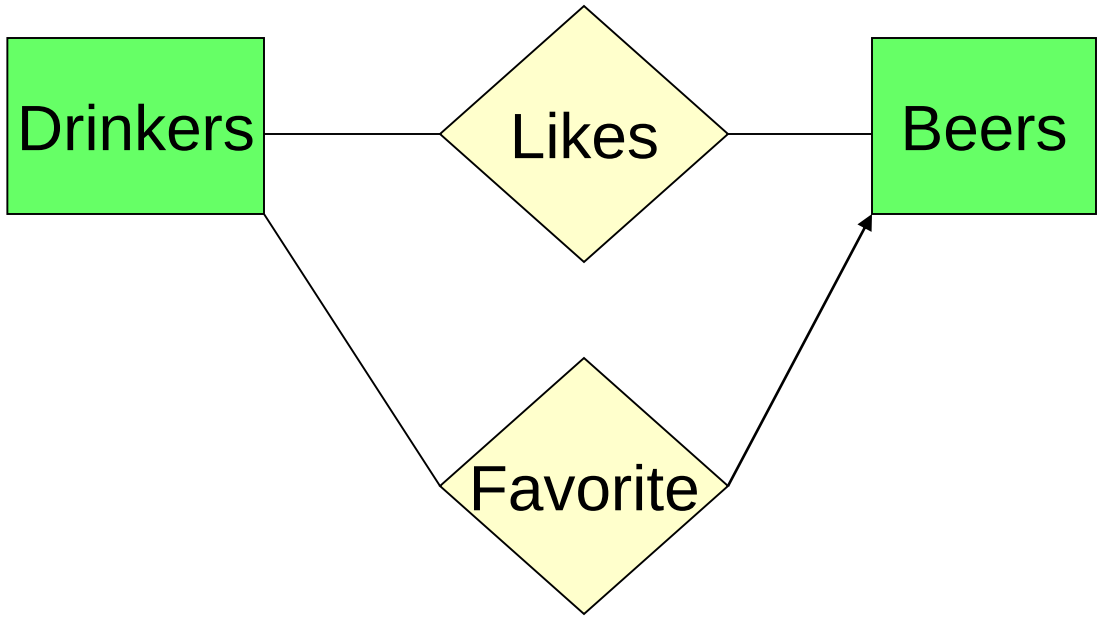
BBD Multiway Relationship



A Typical Relationship Set

Bar	Drinker	Beer
Joe's Bar	Ann	Miller
Sue's Bar	Ann	Bud
Sue's Bar	Ann	Pete's Ale
Joe's Bar	Bob	Bud
Joe's Bar	Bob	Miller
Joe's Bar	Cal	Miller
Sue's Bar	Cal	Bud Lite

Multiple Relationships Between Two Entity Sets



“Exactly one” Multiplicity

Some beers are not the best-seller of any manufacturer, so a **rounded arrow** to *Manfs* would be inappropriate.

But a manufacturer has to have a best-seller.

Exercise 1

- Let us design a database for a bank, including information about customers and their accounts. Information about a customer includes their name, address, phone, and SIN number. Accounts have numbers, types (e.g., savings, checking) and balances. We also need to record the customer(s) who own an account. Draw the E/R diagram for this database.

- Modify your solution as follows:
  a) Change your diagram so an account can have only one customer.
  b) Change your diagram so that a customer can have a set of addresses (which are street-city-province triples) and a set of phones. Remember that we do not allow attributes to have nonatomic types, such as sets, in the E/R model.
  c) Further modify your diagram so that customers can have a set of addresses, and at each address there is a set of phones.

Exercise 2

- Give an E/R diagram for a database recording information about teams, players, and their fans, including:
  1. For each team, its name, its players, its team captain (one of its players), and the colors of its uniform.
  2. For each player, his/her name.
  3. For each fan, his/her name, favorite teams, favorite players, and favorite color.

- Suppose we wish to add to the schema a relationship "Led-by" among two players and a team. The intention is that this relationship set consists of triples

  (player1, player2, team) such that player 1 played on the team at a time when some other player 2 was the team captain.

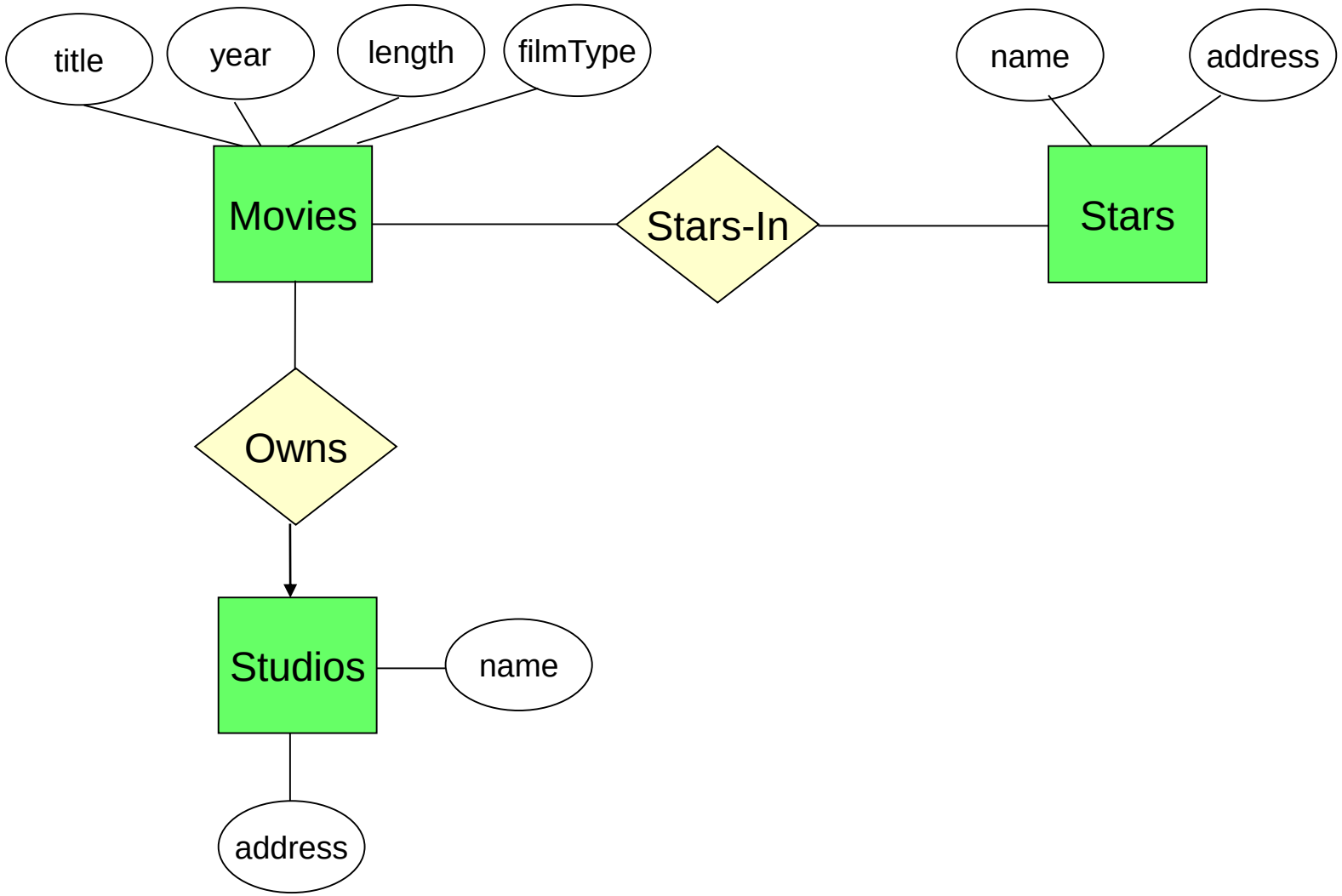
  Draw the modification to the E/R diagram.

Keys

- A *key* (for an entity set) is a set of attributes such that no two entities are the same on all the attributes of the key.

- In E/R, we underline the key attribute(s).

Keys?


title
year
length
filmType
name
address
Movies
Stars-In
Stars
Owns
Studios
name
address

Key for Movies

- Let's consider the entity set **Movie**.

- We might assume that the attribute **title** is a key. However, there can be different movies with the same name:
  - "Godzilla" has several different versions (Japanese, American etc.).

- If we **enforce** in the database a **key constraint** on attribute **title** of **Movie** class, then the **DBMS** will not allow us to insert information about different "Godzilla's".

- A better choice is to take the set **{title, year}** of attributes as a key.
  - We still run the risk that there are two movies made in the same year, with the same title, but that's very unlikely.

Keys for Studios and Stars

- For **Studios:**
  - Reasonable to assume that there are **no** two studios having the **same name**.
  - So, we will enforce **name** to serve as a **key**.

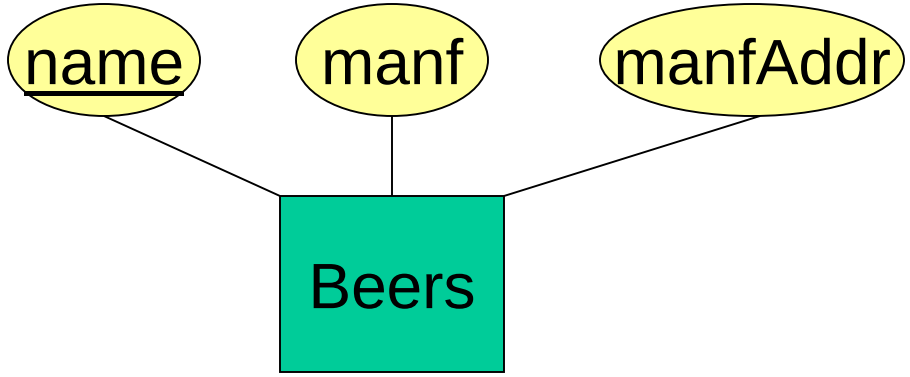
- For **Stars:**
  - We may think that the name can't serve to distinguish two people, but…
  - Yes! For stars the name distinguishes them since traditionally they choose "stage names".
  - So, again here, we will enforce **name** to serve as a **key**.

Surrogate Keys

- Often, people introduce attributes whose role is to serve as a key for classes.
  - Companies assign employee ID's to all employees, and these ID's are carefully chosen to be unique numbers.
  - In Canada everyone has a SIN.
  - Students ID's in universities
  - Driver's license numbers
  - Automobile registration numbers

Entity Sets Versus Attributes I

- Example: Bad design

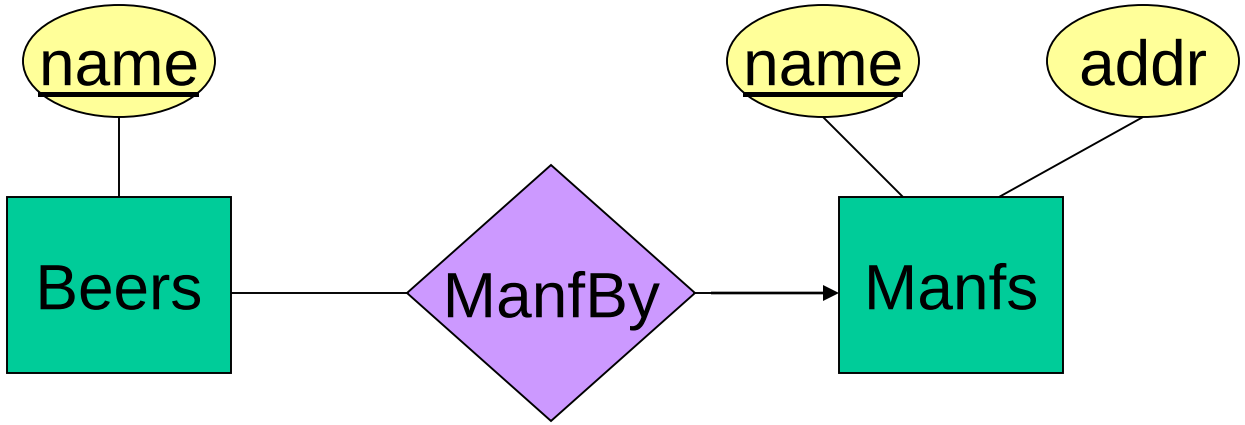


1. Repeats the manufacturer's address once for each beer;
2. Loses the address if there are temporarily no beers for a manufacturer.

Entity Sets Versus Attributes II

- An entity set should satisfy at least one of the following conditions:
  - It is more than the name of something; it has at least one nonkey attribute.

    or
  - It is the “many” in a many-one or many-many relationship.
- Example: Good

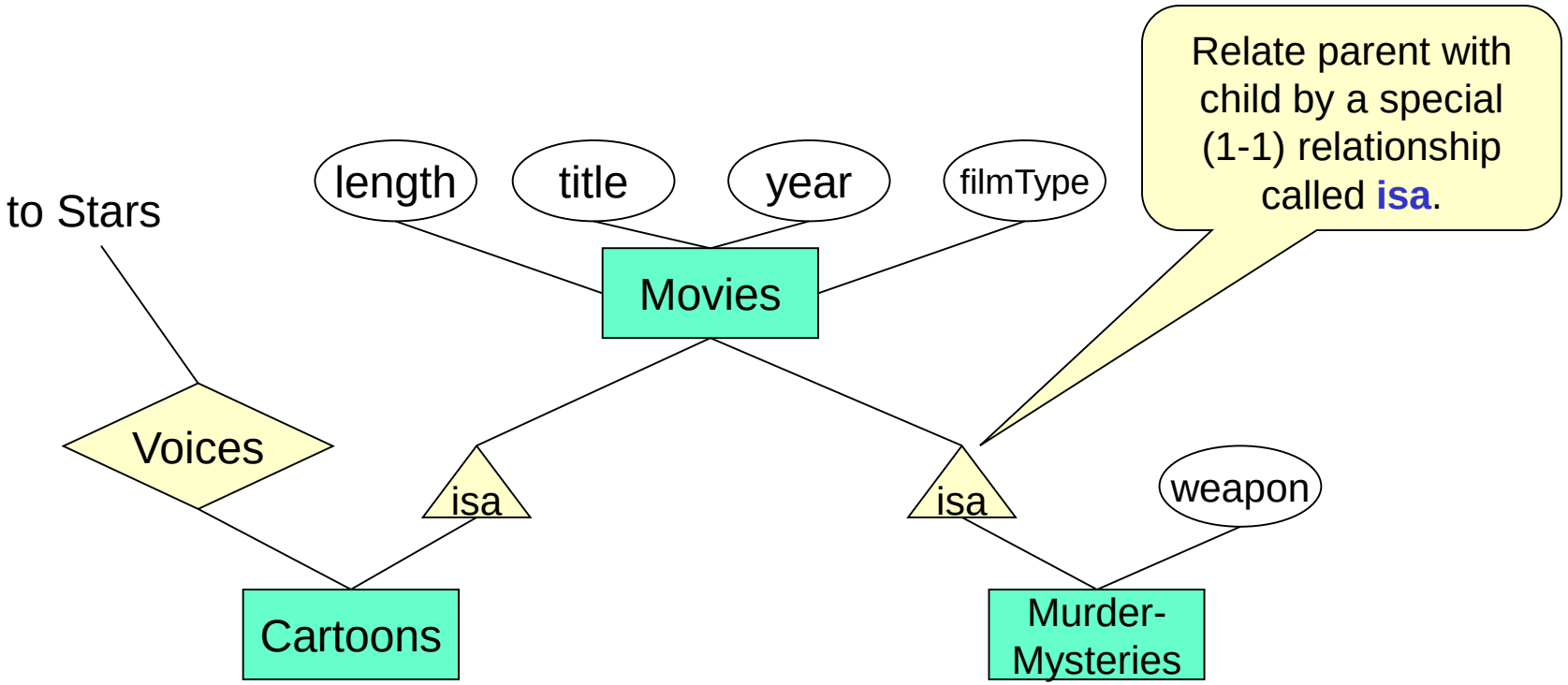


Manfs deserves to be an entity set because of the nonkey attribute *addr*.

Beers deserves to be an entity set because it is the “many” of the many-one relationship *ManfBy*.

Subclasses

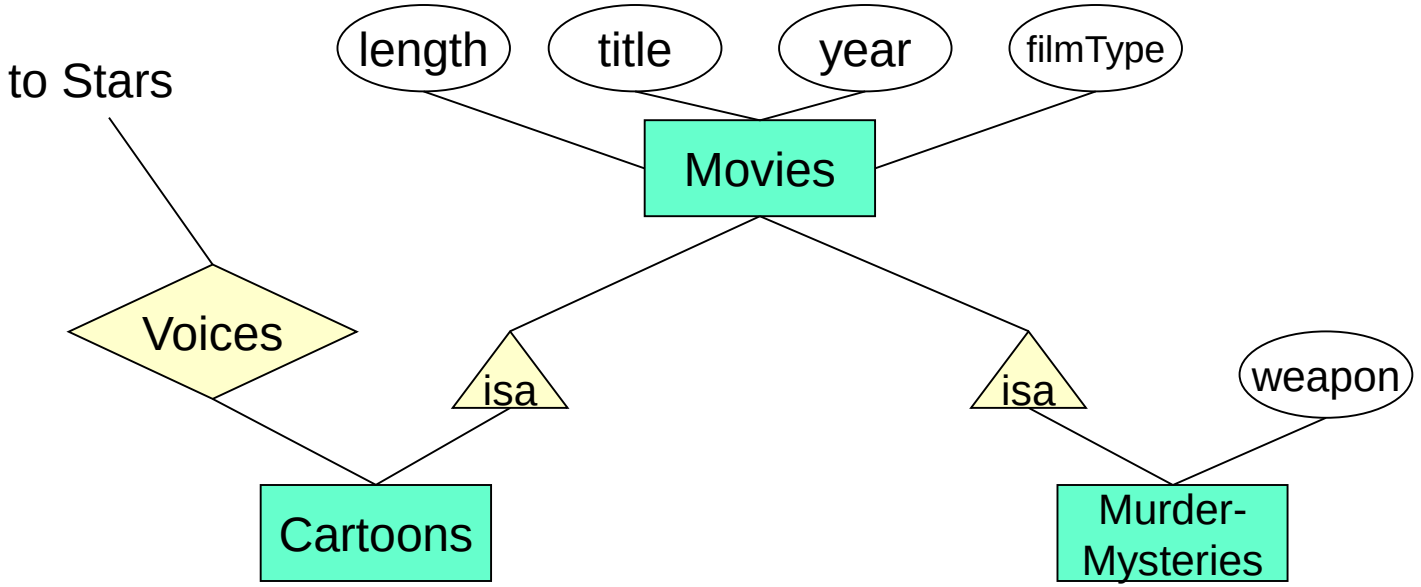
- Sometimes, a class (entity set) contains certain objects (entities) that have special properties not associated with all members of the class.



Inheritance in the E/R Model

- E/R entities have components in all subclasses to which they belong.

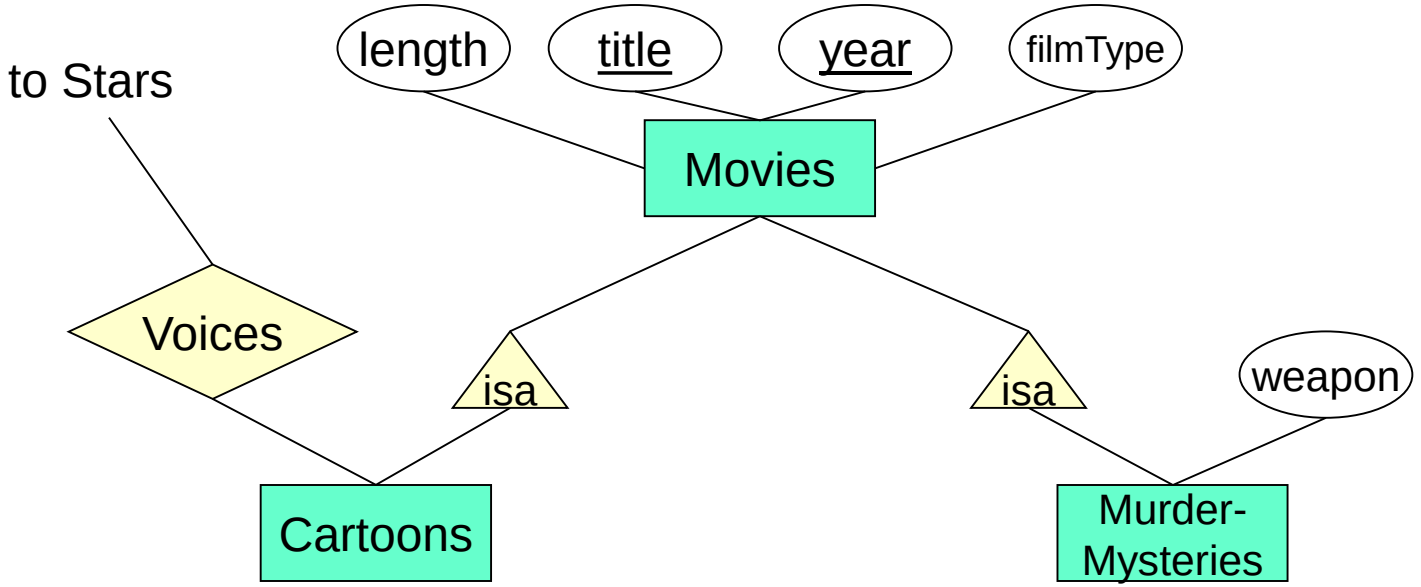
- **Example**: **Roger Rabit**, which is both a **cartoon** and **murder-mystery**
  - will have components in all three entity sets: **Movies**, **Cartoons**, **Murder-Mysteries**.
  - i.e. it will have all four attributes of **Movies**, the attribute **weapon**, and finally will participate in the relationship **voices**.



Keys for entity set hierarchies

Key of root is **key for all**.

E.g. **{title,year}** is the key for **Movies**, **Cartoons** and **Murder-Mysteries**.



Weak Entity Sets

- Occasionally, entities of an entity set need “help” to identify them uniquely.

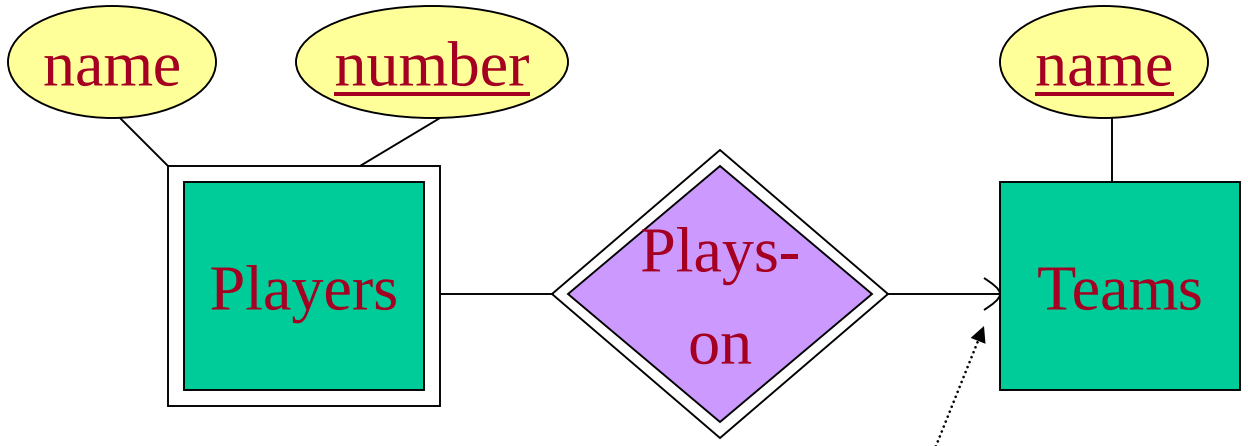
- Entity set *E* is said to be weak if

  in order to identify entities of *E* uniquely, we need to follow one or more **many-one** relationships from *E* and include the key of the related entities from the connected entity sets.

Example: Weak Entity Set

- name is almost a key for **football players**, but there might be two with the same name.
- number is certainly not a key, since players on two teams could have the same number.
- But number, together with the team name related to the player by Plays-on should be unique.

In E/R Diagrams



Note: must be rounded
because each player needs
a team to help with the key.

- Double diamond for **supporting** many-one relationship.
- Double rectangle for the weak entity set.

Weak Entity-Set Rules

- A weak entity set has one or more **many-one relationships** to other (supporting) entity sets.
  - Not every many-one relationship from a weak entity set need be supporting.
  - But supporting relationships must have a rounded arrow (entity at the “one” end is guaranteed).

- The key for a weak entity set is its own underlined attributes and the keys for the supporting entity sets.
  - E.g., (player) number and (team) name is a key for Players in the previous example.

Optional

CROW'S FOOT NOTATION

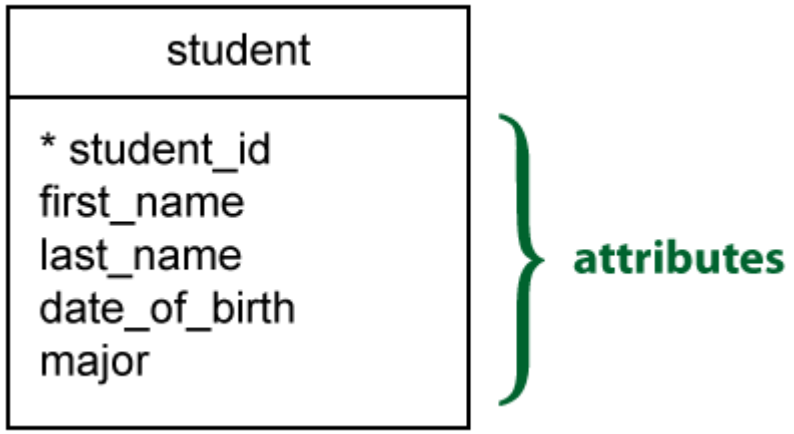
Reference: http://www.vertabelo.com/blog/technical-articles/crow-s-foot-notation

Intro

- What we have seen so far is known as **Chen’s notation**.

- Another popular notation is the **Crow’s foot notation**.

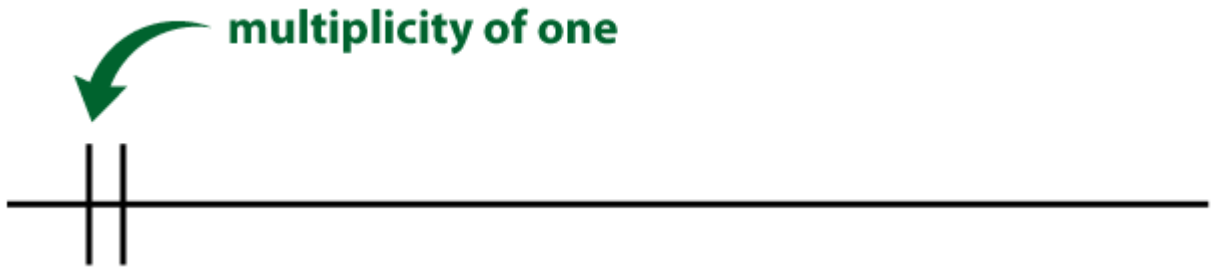
Entity

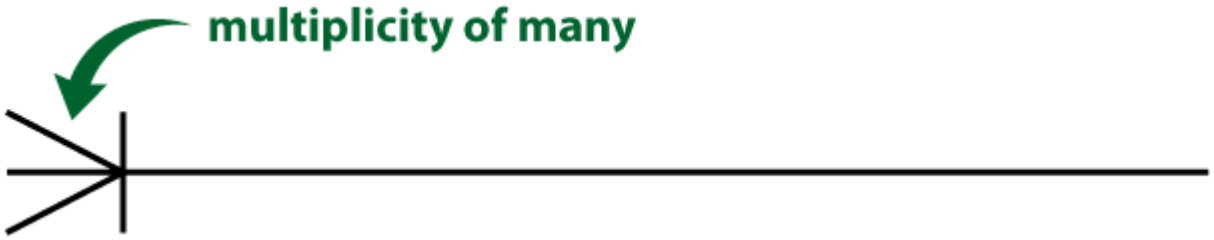

student
* student_id
first_name
last_name
date_of_birth
major
attributes

Relationships

Relationships have two indicators. These are shown on both sides of the line.

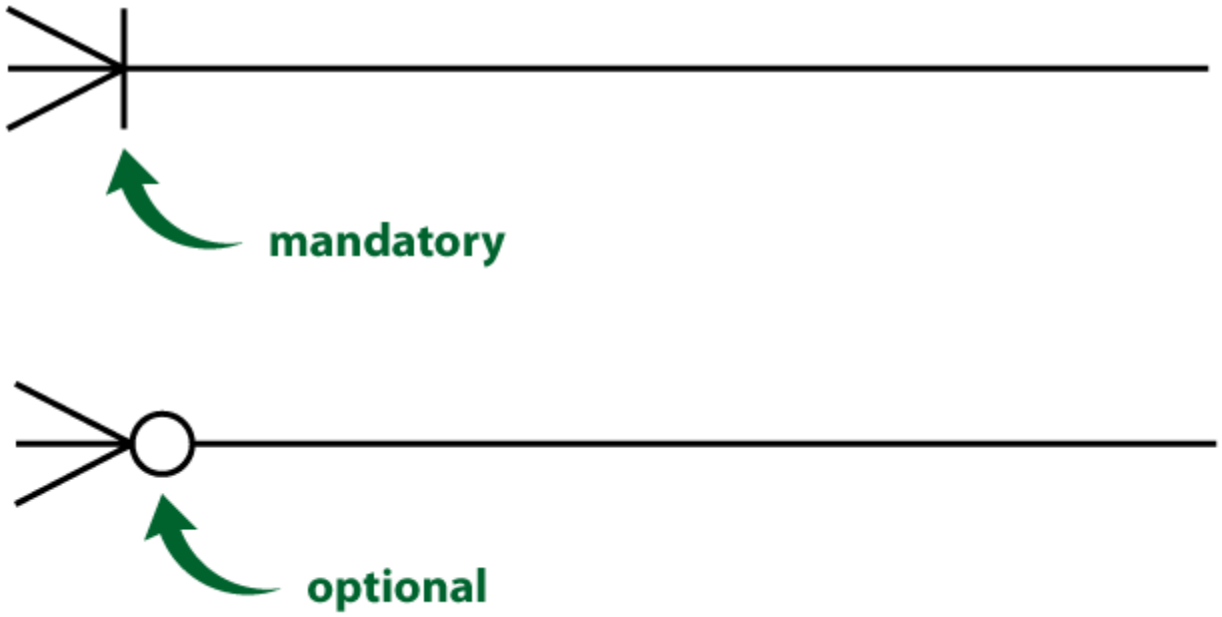
The first one (often called **multiplicity**) refers to the *maximum* number of times that an instance of one entity can be associated with instances in the related entity. It can be **one** or **many**.





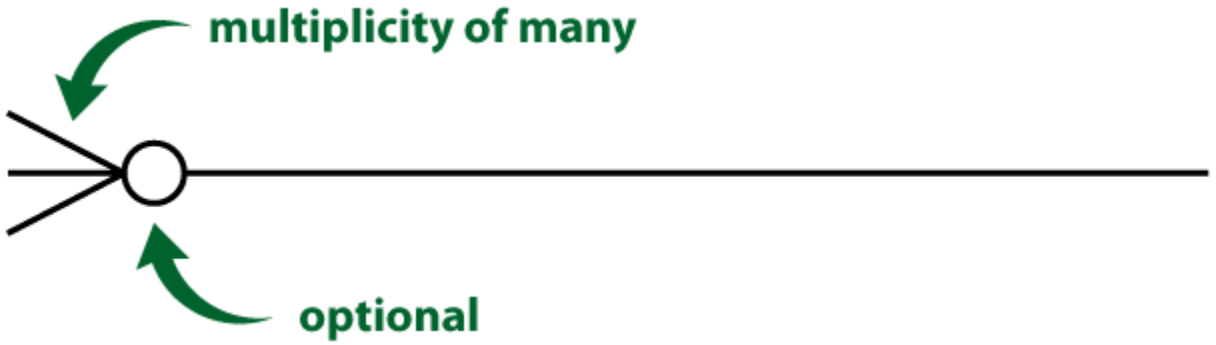
Relationships

The second describes the *minimum* number of times one instance can be related to others. It can be **zero** or **one**, and accordingly describes the relationship as **optional** or **mandatory**.



Relationships – Four Possibilities

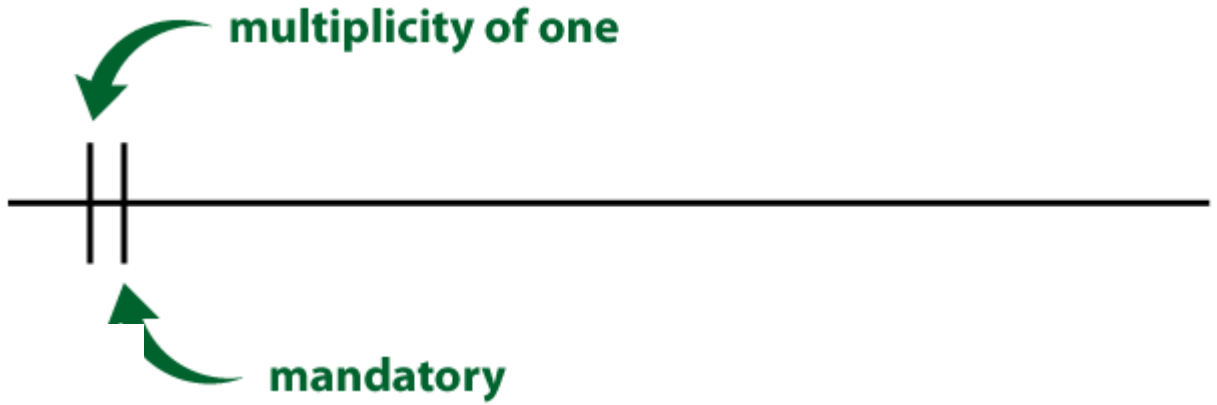
zero or many



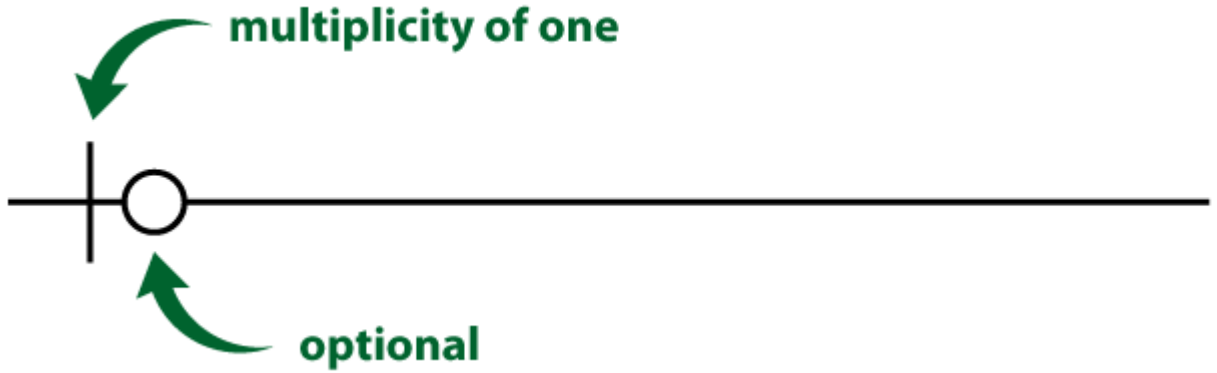
one or many

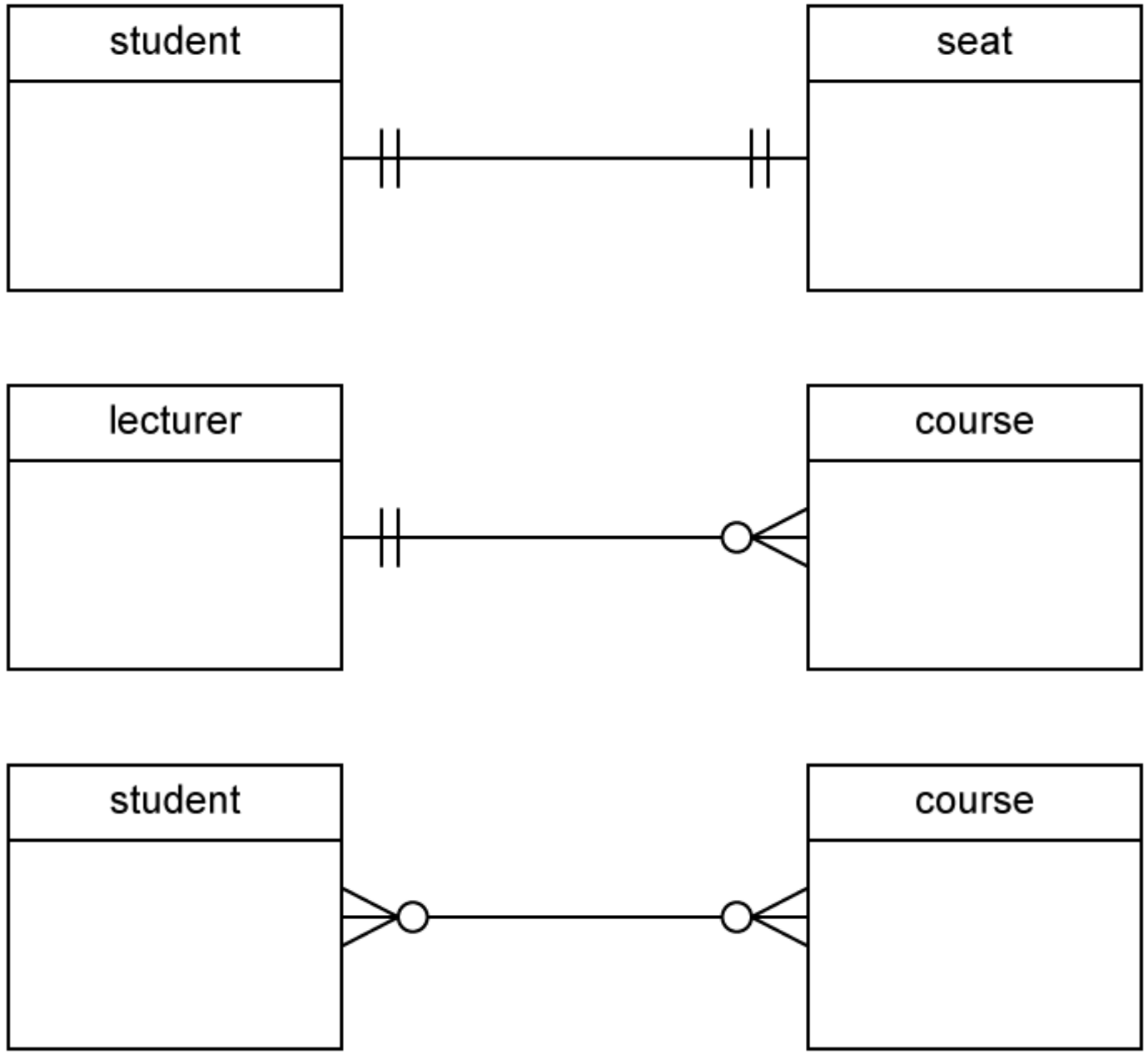
Relationships – Four Possibilities

one and only one



zero or one




student
seat
lecturer
course
student
course