Entity-Relationship Model

Diagrams

Class hierarchies

Weak entity sets

Purpose of E/R Model

- The E/R model allows us to sketch database designs.
  - Kinds of data and how they connect.
  - Not how data changes.
- Designs are pictures called *entity-relationship diagrams*.
- Later: convert E/R designs to relational DB designs.

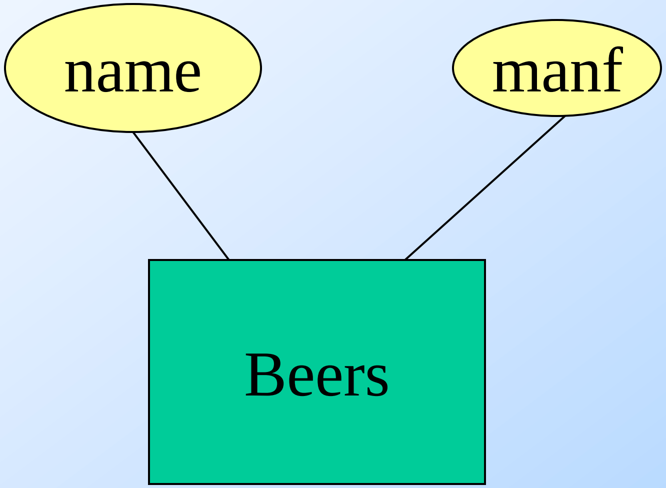
Entity Sets

- *Entity* = "thing" or object.
- *Entity set* = collection of similar entities.
  - Similar to a class in object-oriented languages.
- *Attribute* = property of (the entities of) an entity set.
  - Attributes are simple values, e.g. integers or character strings.

E/R Diagrams

- In an entity-relationship diagram:
  - Entity set = rectangle.
  - Attribute = oval, with a line to the rectangle representing its entity set.

Example

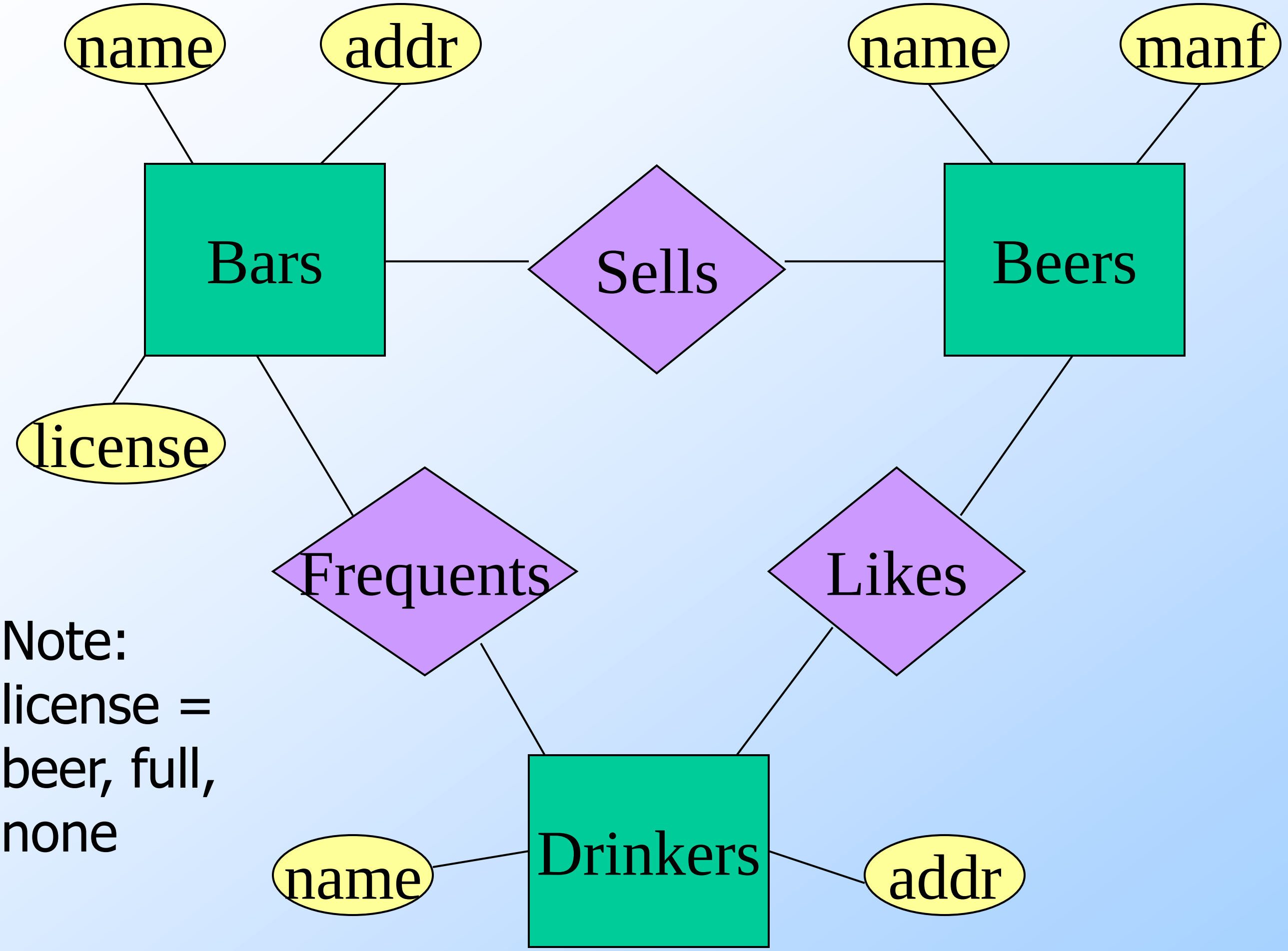


- Entity set Beers has two attributes, name and manf (manufacturer).
- Each Beers entity has values for these two attributes, e.g. (Bud, Anheuser-Busch)

Relationships

- A relationship connects two or more entity sets.
- It is represented by a diamond, with lines to each of the entity sets involved.

Example



Note:
license =
beer, full,
none

Bars sell some beers.

Drinkers like some beers.

Drinkers frequent some bars.

Relationship Set

- The current "value" of an entity set is the set of entities that belong to it.
  - Example: the set of all bars in our database.
- The "value" of a relationship is a set of lists of currently related entities, one from each of the related entity sets.

Example

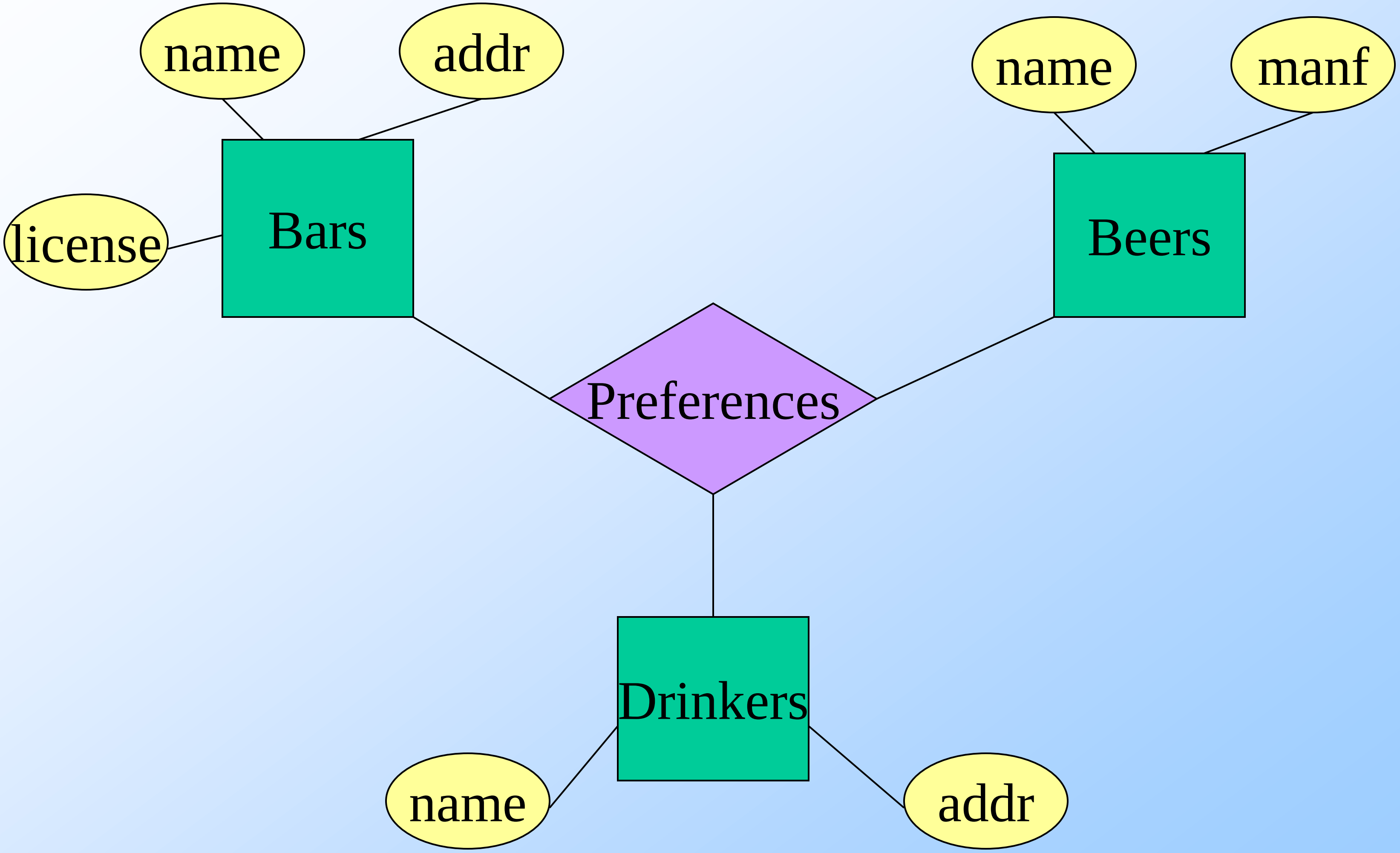
- For the relationship Sells, we might have a relationship set like:

Bar	Beer
Joe’s Bar	Bud
Joe’s Bar	Miller
Sue’s Bar	Bud
Sue’s Bar	Pete’s Ale
Sue’s Bar	Bud Lite

Multiway Relationships

- Sometimes, we need a relationship that connects more than two entity sets.
- Suppose that drinkers will only drink certain beers at certain bars.
  - Our three binary relationships Likes, Sells, and Frequents do not allow us to make this distinction.
  - But a 3-way relationship would.

Example


name
addr
license
Bars
name
manf
Beers
Preferences
Drinkers
name
addr

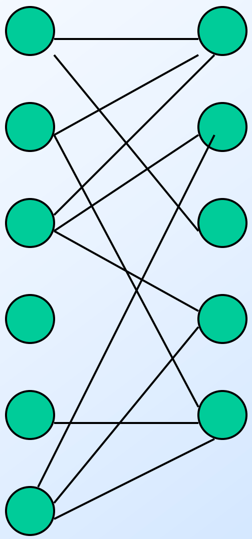
A Typical Relationship Set

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

Many-Many Relationships

- Focus: binary relationships, such as Sells between Bars and Beers.
- In a *many-many* relationship, an entity of either set can be connected to many entities of the other set.
  - E.g., a bar sells many beers; a beer is sold by many bars.

In Pictures:

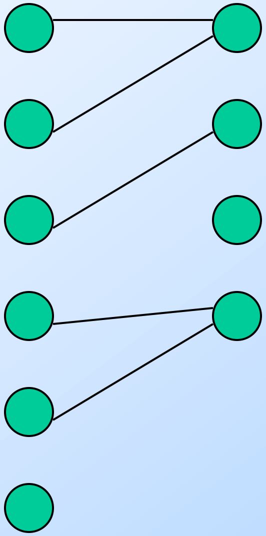


many-many

Many-One Relationships

- Some binary relationships are *many -one* from one entity set to another.
- Each entity of the first set is connected to at most one entity of the second set.
- But an entity of the second set can be connected to zero, one, or many entities of the first set.

In Pictures:



many-one

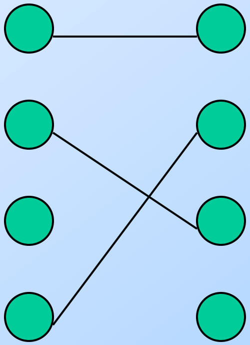
Example

- Favorite, from Drinkers to Beers is many-one.
- A drinker has at most one favorite beer.
- But a beer can be the favorite of any number of drinkers, including zero.

One-One Relationships

- In a *one-one* relationship, each entity of either entity set is related to at most one entity of the other set.
- Example: Relationship Best-seller between entity sets Manfs (manufacturer) and Beers.
  - A beer cannot be made by more than one manufacturer, and no manufacturer can have more than one best-seller (assume no ties).

In Pictures:

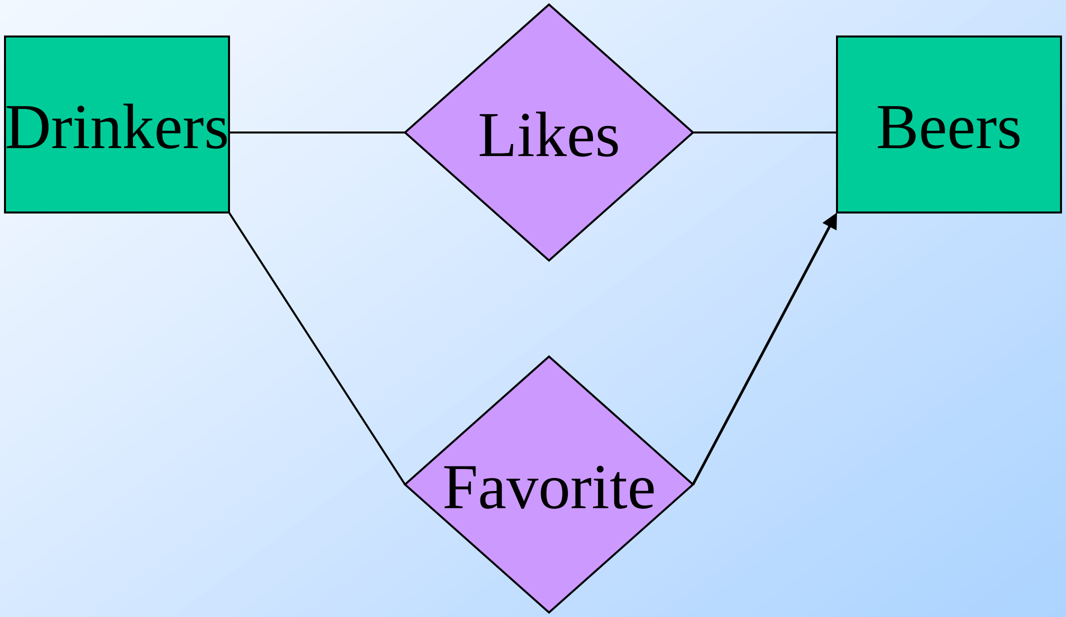


one-one

Representing “Multiplicity”

- Show a many-one relationship by an arrow entering the “one” side.
- Show a one-one relationship by arrows entering both entity sets.
- Rounded arrow = “exactly one,” i.e., each entity of the first set is related to exactly one entity of the target set.

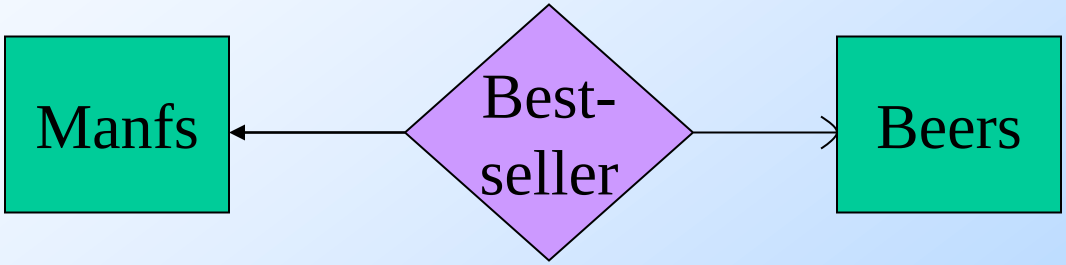
Example



Example

- Consider Best-seller between Manfs and Beers.
- Some beers are not the best-seller of any manufacturer, so a rounded arrow to Manfs would be inappropriate.
- But a beer manufacturer has to have a best-seller.

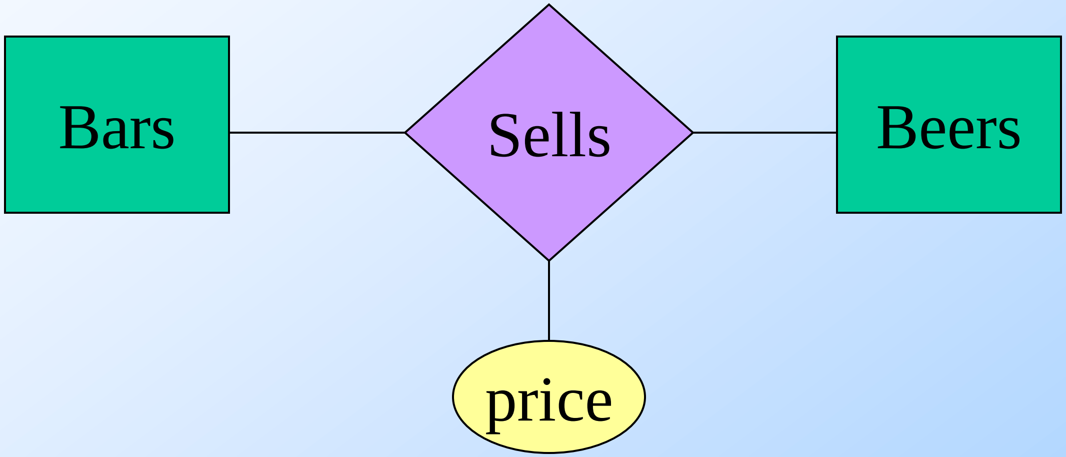
In the E/R Diagram



Attributes on Relationships

- Sometimes it is useful to attach an attribute to a relationship.
- Think of this attribute as a property of tuples in the relationship set.

Example

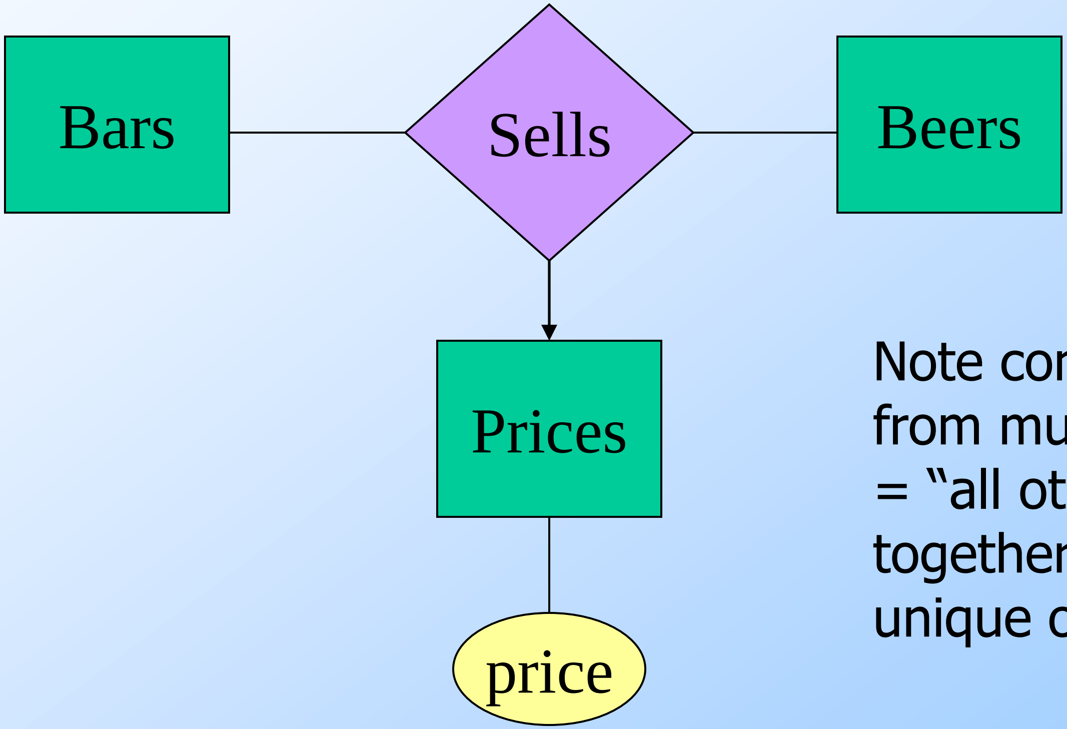


Price is a function of both the bar and the beer, not of one alone.

Equivalent Diagrams Without Attributes on Relationships

- Create an entity set representing values of the attribute.
- Make that entity set participate in the relationship.

Example



Note convention: arrow from multiway relationship = "all other entity sets together determine a unique one of these."

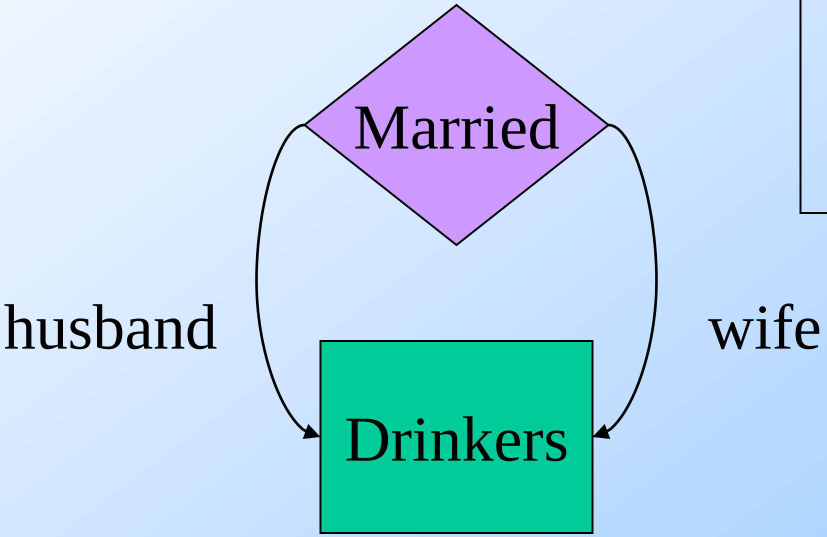
Roles

- Sometimes an entity set appears more than once in a relationship.
- Label the edges between the relationship and the entity set with names called *roles*.

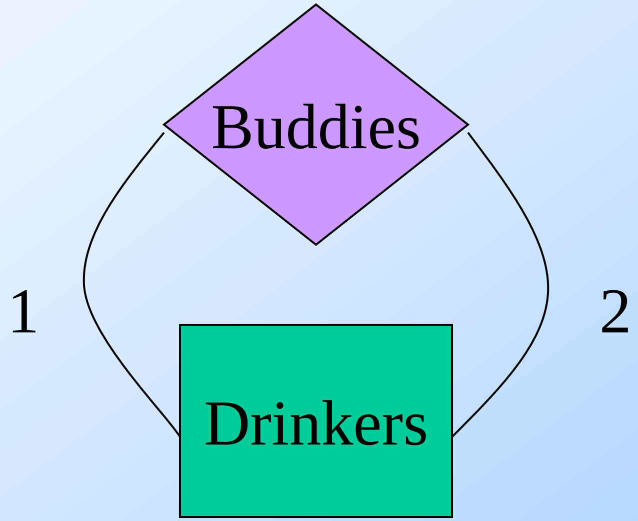
Example

Relationship Set

Husband	Wife
Bob	Ann
Joe	Sue
…	…



Example



Relationship Set

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

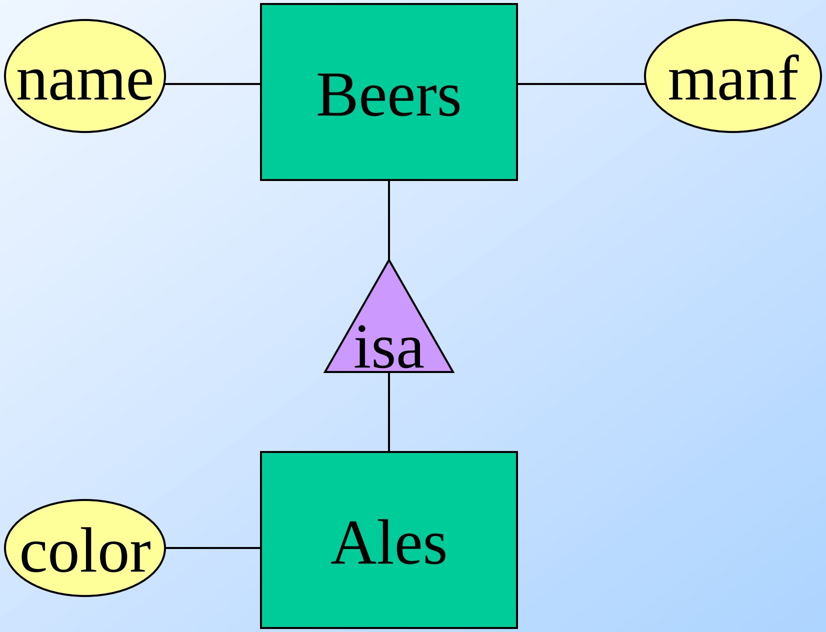
Subclasses

- *Subclass* = special case = fewer entities = more properties.
- Example: Ales are a kind of beer.
  - Not every beer is an ale, but some are.
  - Let us suppose that in addition to all the *properties* (attributes and relationships) of beers, ales also have the attribute color.

Subclasses in E/R Diagrams

- Assume subclasses form a tree.
  - I.e., no multiple inheritance.
- Isa triangles indicate the subclass relationship.
  - Point to the superclass.

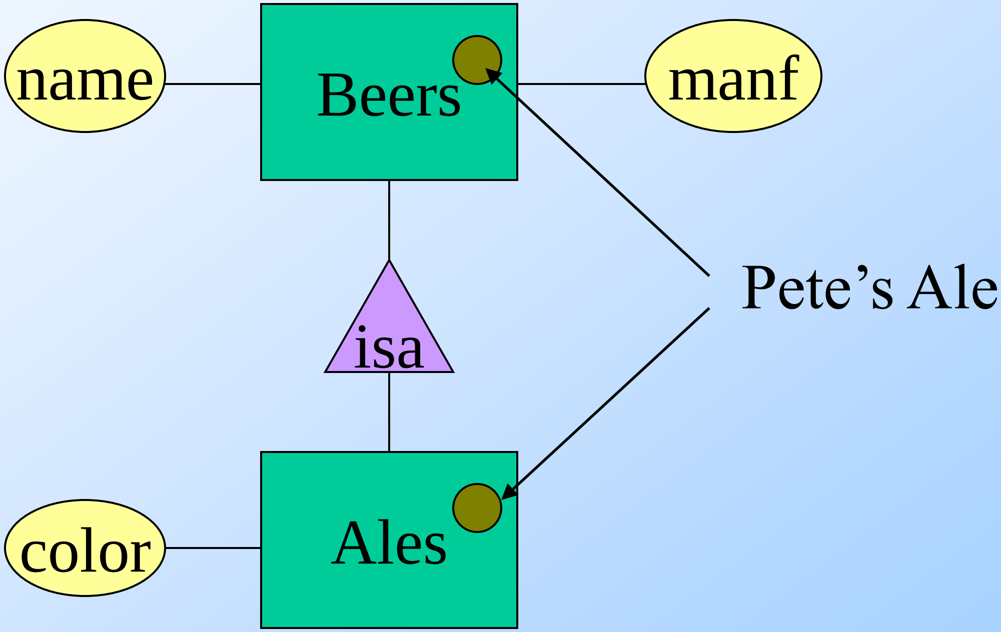
Example



E/R Vs. Object-Oriented Subclasses

- In OO, objects are in one class only.
  - Subclasses inherit from superclasses.
- In contrast, E/R entities have representatives in all subclasses to which they belong.
  - Rule: if entity *e* is represented in a subclass, then *e* is represented in the superclass.

Example



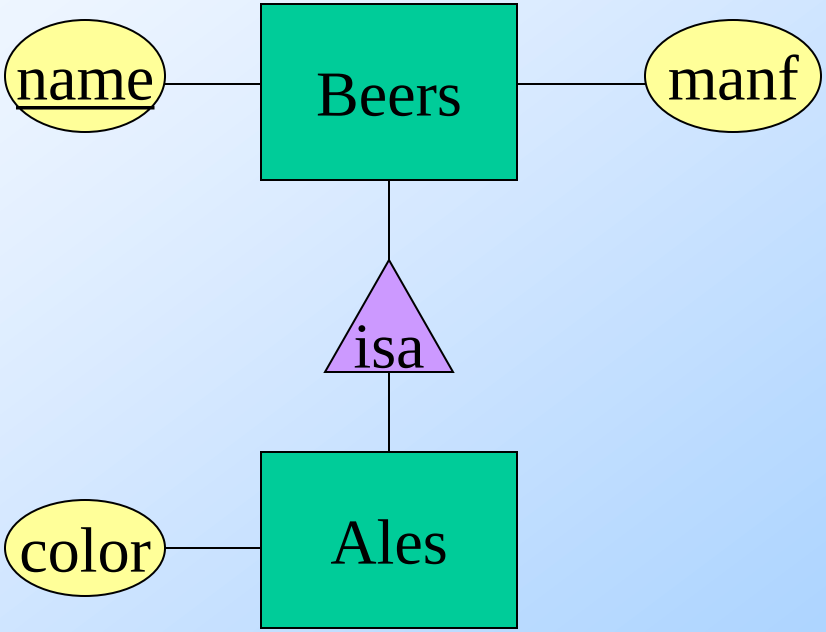
Keys

- A *key* is a set of attributes for one entity set such that no two entities in this set agree on all the attributes of the key.
  - It is allowed for two entities to agree on some, but not all, of the key attributes.
- We must designate a key for every entity set.

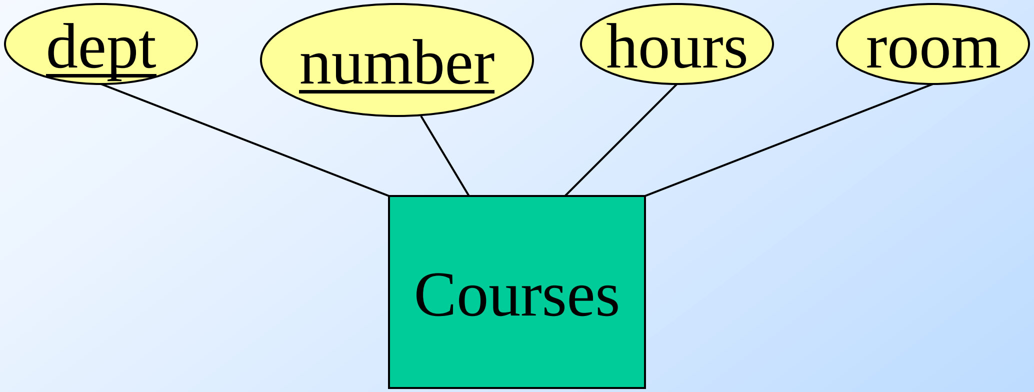
Keys in E/R Diagrams

- Underline the key attribute(s).
- In an Isa hierarchy, only the root entity set has a key, and it must serve as the key for all entities in the hierarchy.

Example: name is Key for Beers



Example: a Multi-attribute Key



- Note that hours and room could also serve as a key, but we must select only one key.

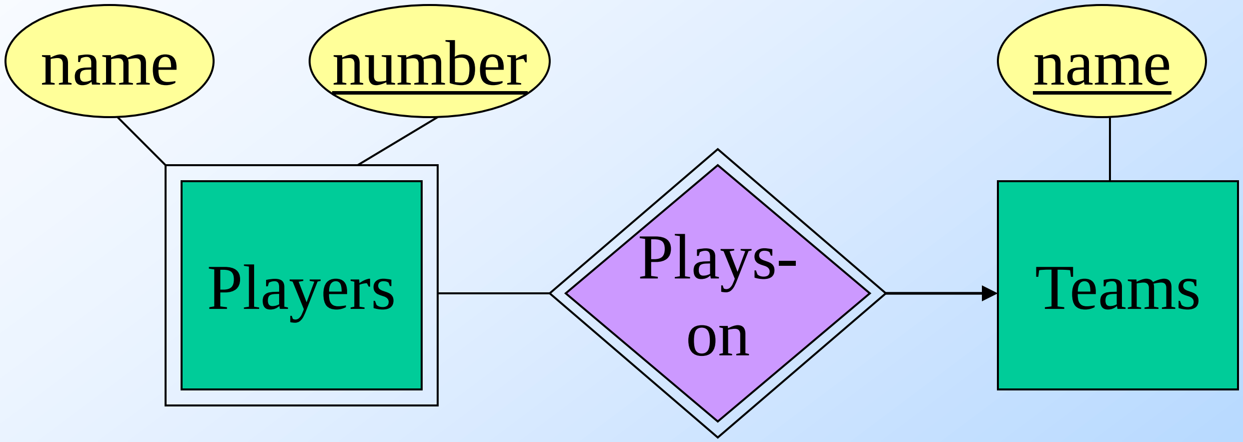
Weak Entity Sets

- 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

- 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



- 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.
- 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.

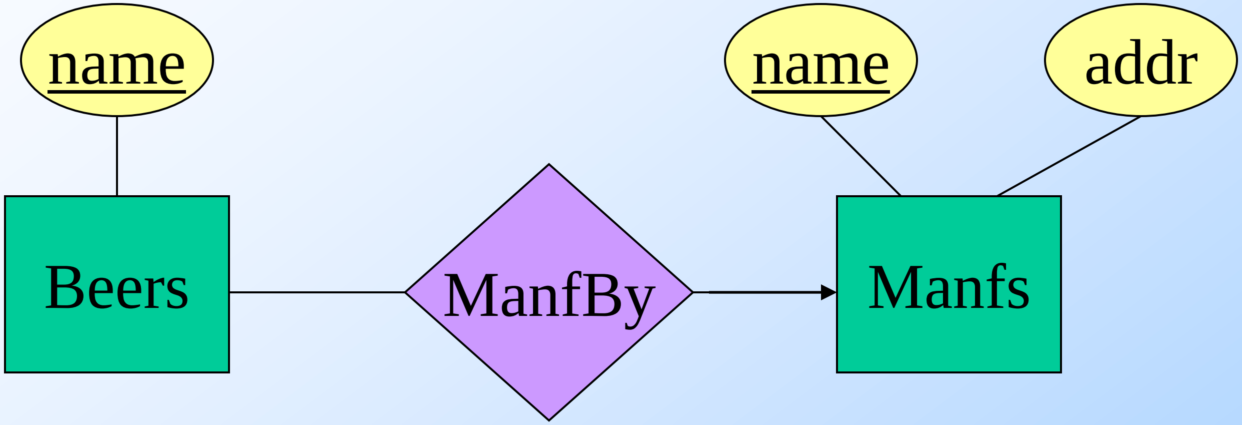
Design Techniques

1. Avoid redundancy.
2. Limit the use of weak entity sets.
3. Don’t use an entity set when an attribute will do.

Avoiding Redundancy

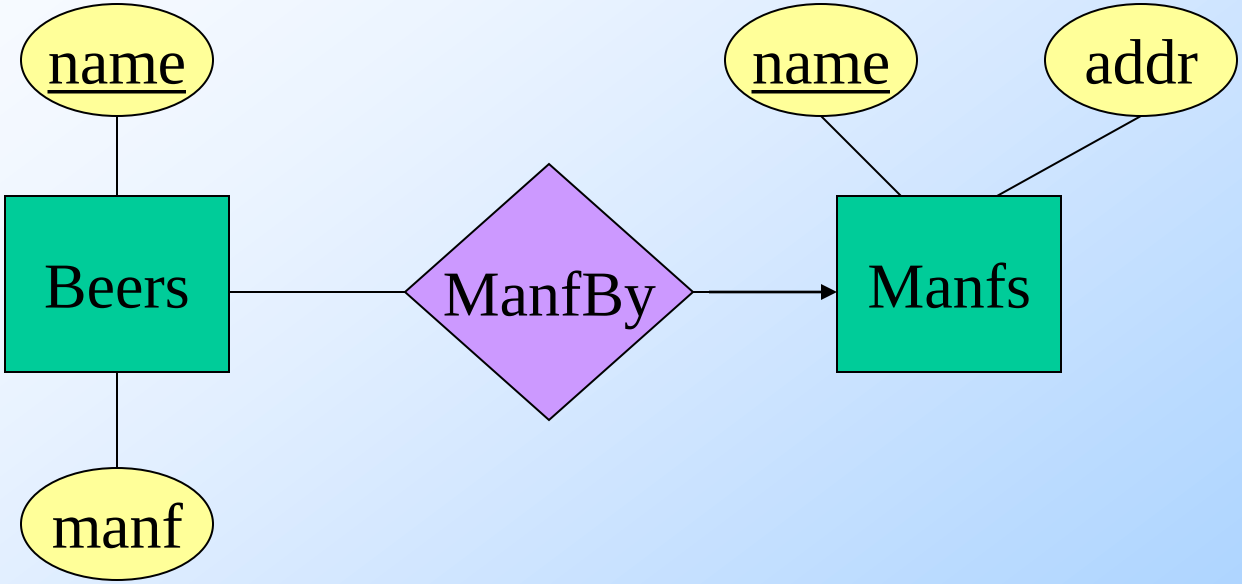
- *Redundancy* occurs when we say the same thing in two or more different ways.
- Redundancy wastes space and (more importantly) encourages inconsistency.
  - The two instances of the same fact may become inconsistent if we change one and forget to change the other.

Example: Good



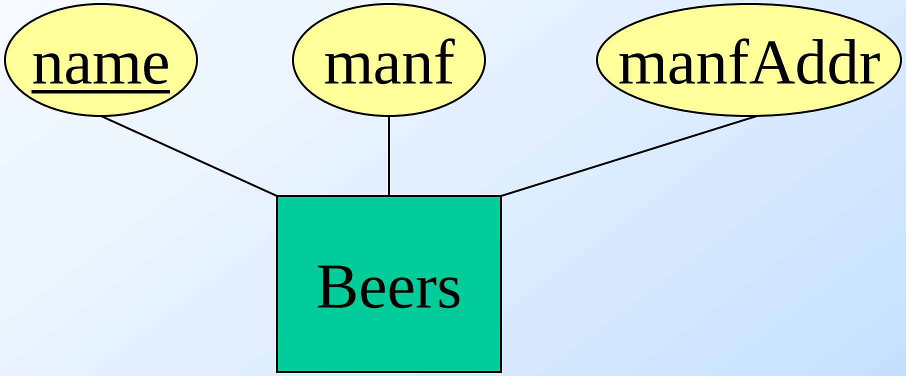
This design gives the address of each manufacturer exactly once.

Example: Bad



This design states the manufacturer of a beer twice: as an attribute and as a related entity.

Example: Bad



This design repeats the manufacturer’s address once for each beer and loses the address if there are temporarily no beers for a manufacturer.

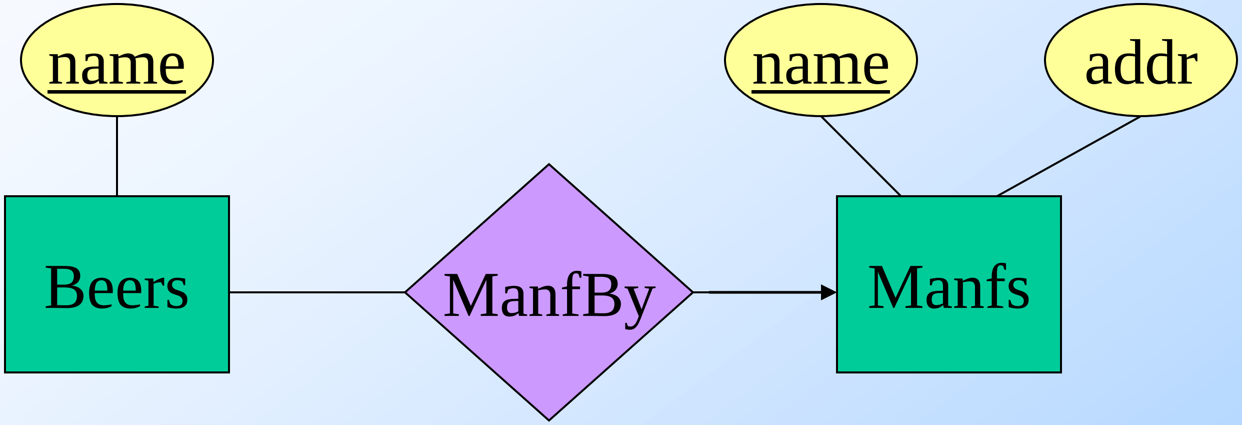
Entity Sets Versus Attributes

- 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

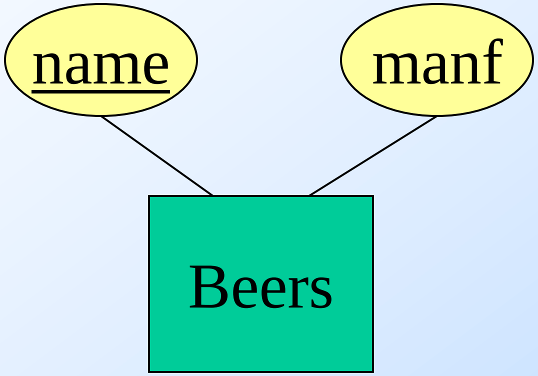
  - It is the “many” in a many-one or many-many relationship.

Example: Good



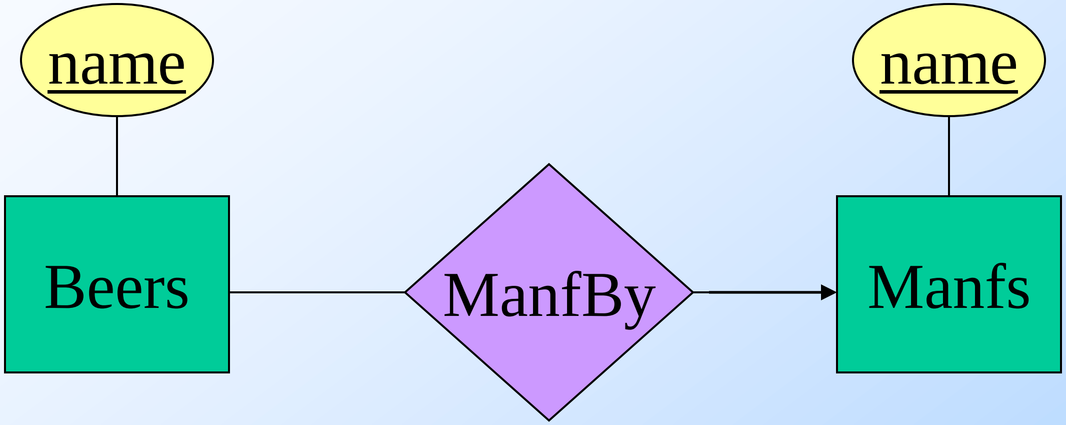
- Manfs deserves to be an entity set because of the nonkey attribute addr.
- Beers deserves to be an entity set because it is the “many” of the many-one relationship ManfBy.

Example: Good



There is no need to make the manufacturer an entity set, because we record nothing about manufacturers besides their name.

Example: Bad



Since the manufacturer is nothing but a name, and is not at the “many” end of any relationship, it should not be an entity set.

Don’t Overuse Weak Entity Sets

- Beginning database designers often doubt that anything could be a key by itself.
  - They make all entity sets weak, supported by all other entity sets to which they are linked.
- In reality, we usually create unique ID’s for entity sets.
  - Examples include social-security numbers, automobile VIN’s etc.

When Do We Need Weak Entity Sets?

- The usual reason is that there is no global authority capable of creating unique ID's.
- Example: it is unlikely that there could be an agreement to assign unique player numbers across all football teams in the world.