Entity-Relationship Model

E/R DIAGRAMS

WEAK ENTITY SETS

CONVERTING E/R DIAGRAMS TO RELATIONS

Purpose of E/R Model

The E/R model allows us to sketch database schema designs.

- Includes some constraints but not operations.

Designed schemas are called *entity-relationship diagrams*.

Later: convert E/R diagrams to relations.

Framework for E/R

Design is a serious business!

The “boss” knows they want a database, but they do not know what they want in it.

Sketching the key components is an efficient way to develop a working database.

Entity Sets

Entity = “thing” or object.

Entity set = collection of similar entities.

Attribute = property of an entity set.

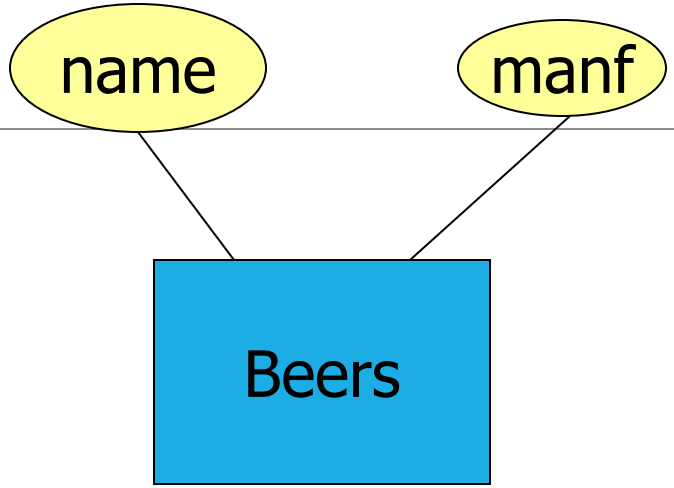
- Attributes are simple values, e.g. integers or character strings, not structs, sets, etc.

E/R Diagrams

In an entity-relationship diagram:

- Entity set = rectangle.
- Attribute = oval, with a line to 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)

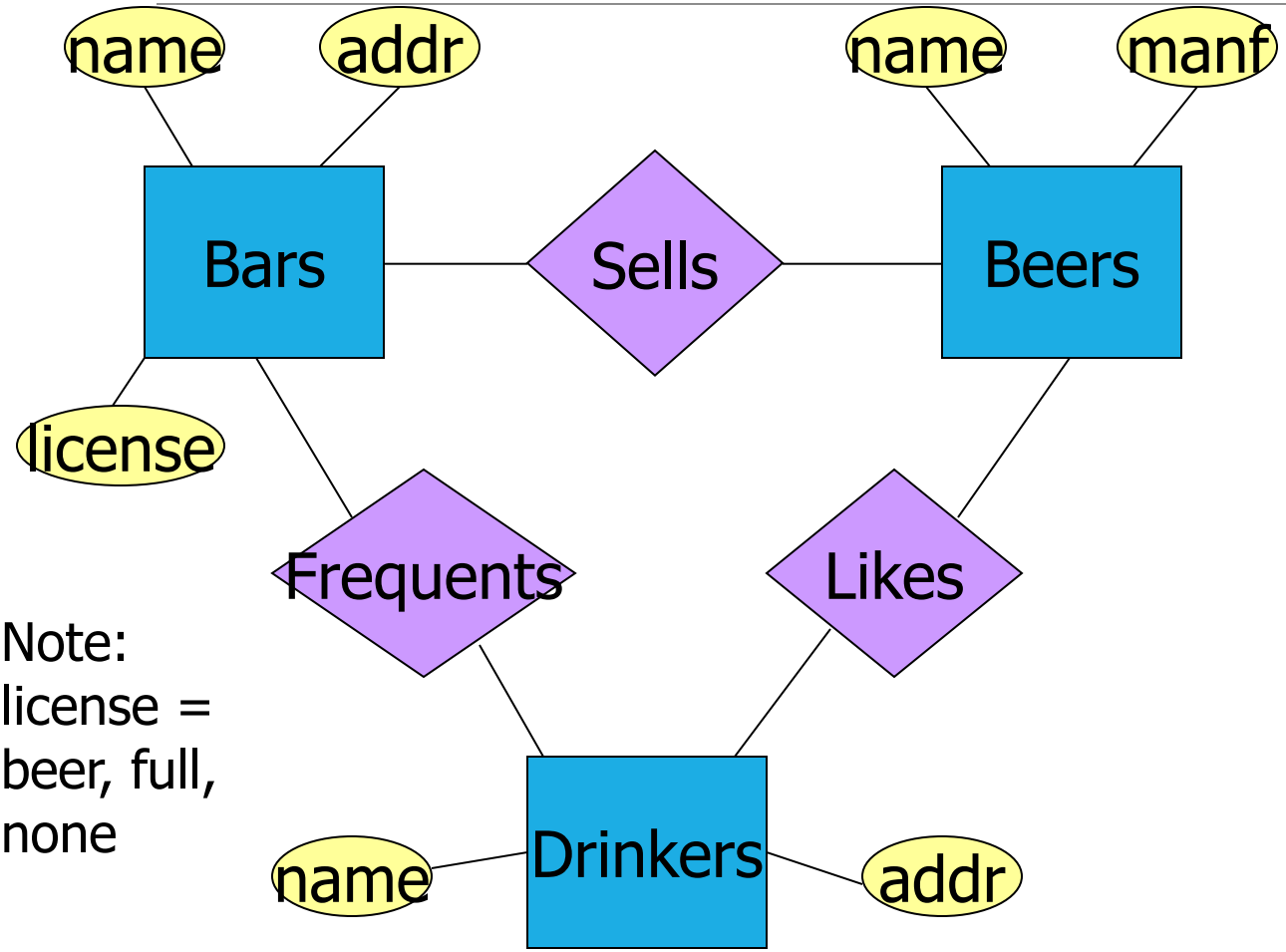
Relationships

A relationship connects two (or more) entity sets.

It is represented by a diamond

- with lines to each of the entity sets involved.

Example: Relationships



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 *relationship set*, a set of tuples with one component for each related entity set.

Example: Relationship Set

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

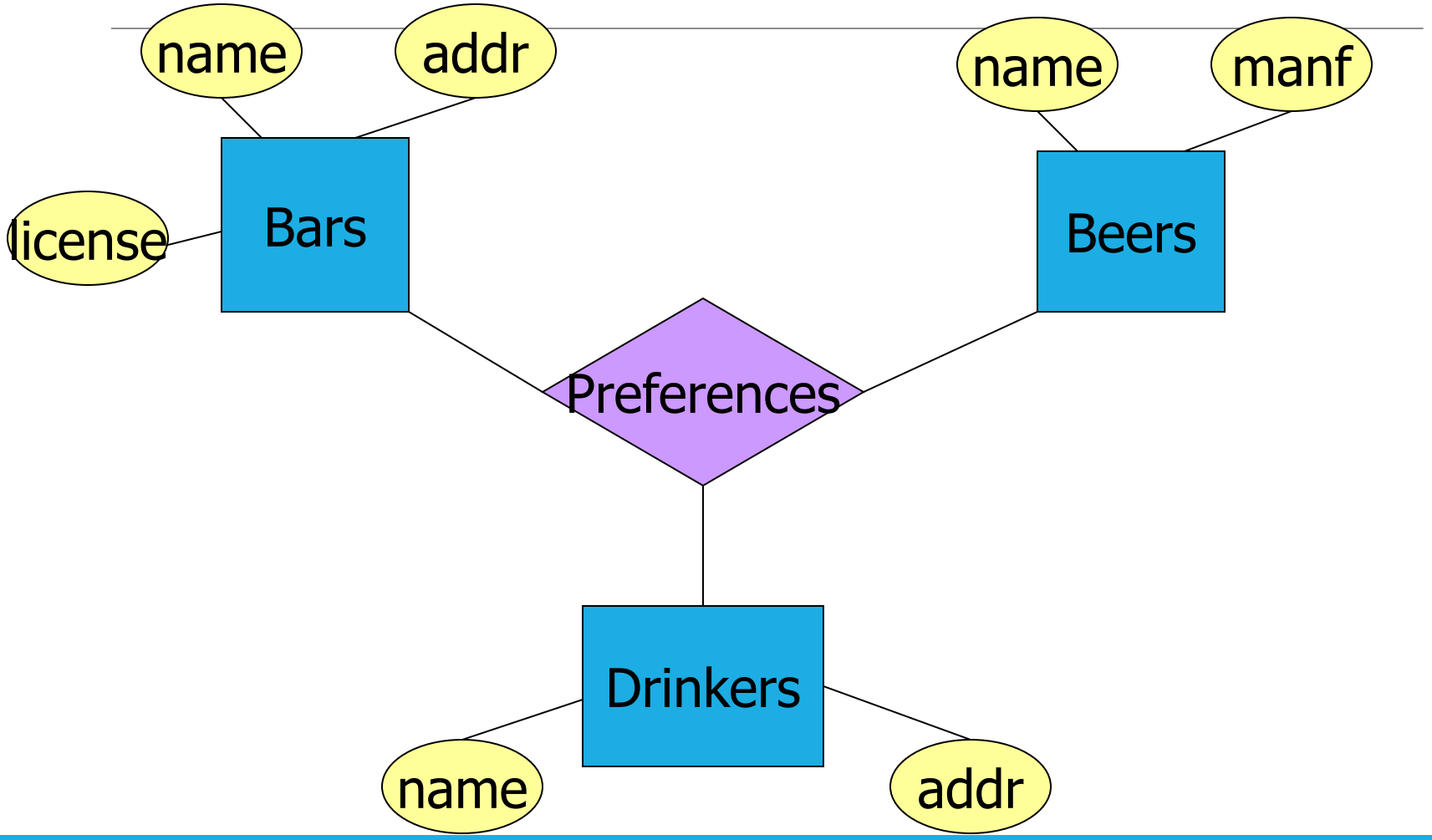
Multiway Relationships

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: 3-Way Relationship



A Typical Relationship Set

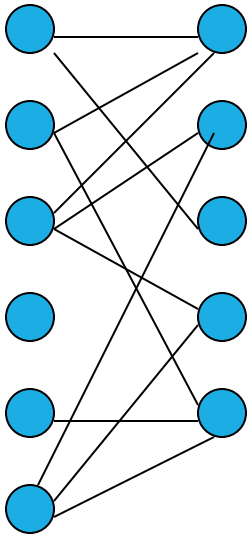
Bar	Drinker	Beer
Joe's Bar	Ann	Miller
Sue's Bar	Ann	Bud
Sue's Bar	Ann	Pete's Ale
Joe's Bar	Bob	Bud
Joe's Bar	Bob	Miller
Joe's Bar	Cal	Miller
Sue's Bar	Cal	Bud Lite

Many-Many Relationships

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

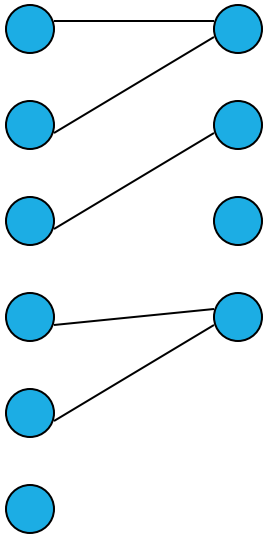
Many-One Relationships

Some 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: Many-One Relationship

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.

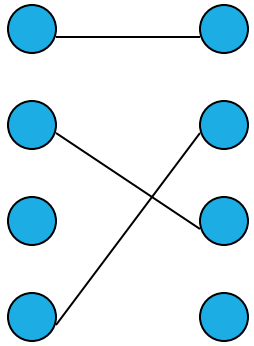
One-One Relationships

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

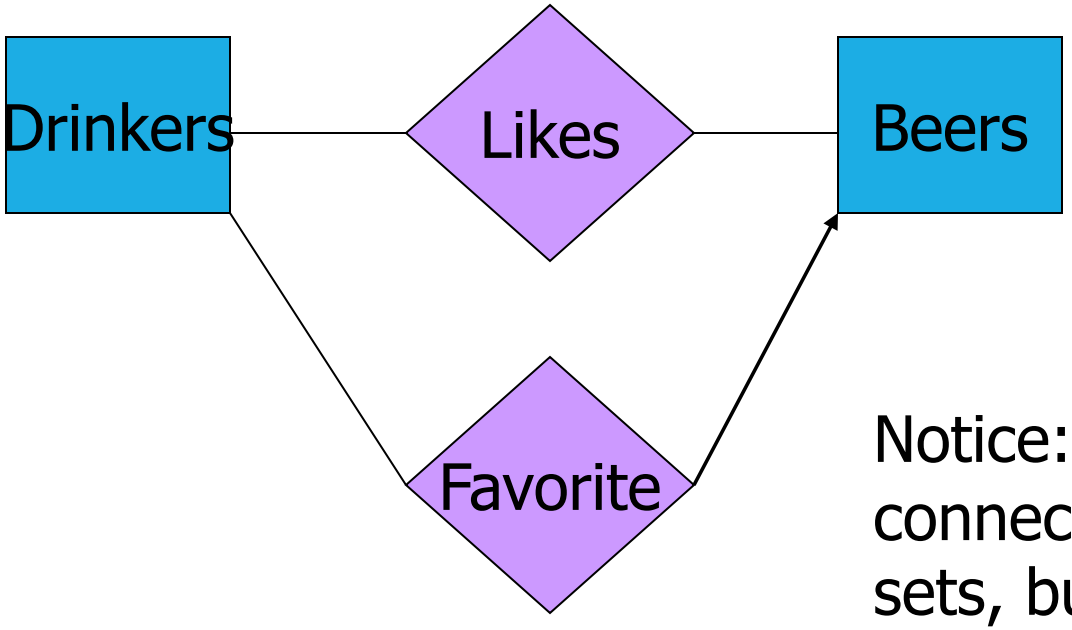
Representing “Multiplicity”

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: Many-One Relationship



Notice: two relationships connect the same entity sets, but are different.

Example: One-One Relationship

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

A beer is the best-seller for 0 or 1 manufacturer.

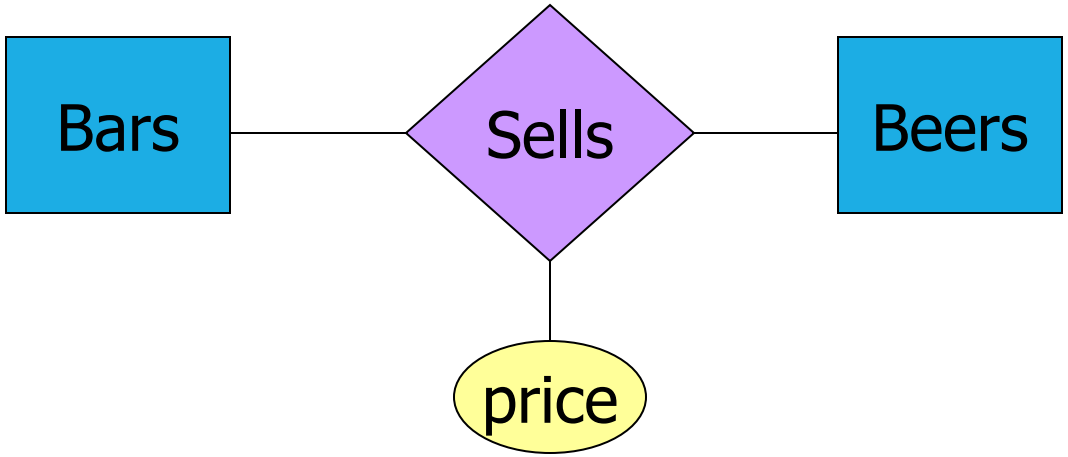
A manufacturer has exactly one best seller.

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: Attribute on Relationship



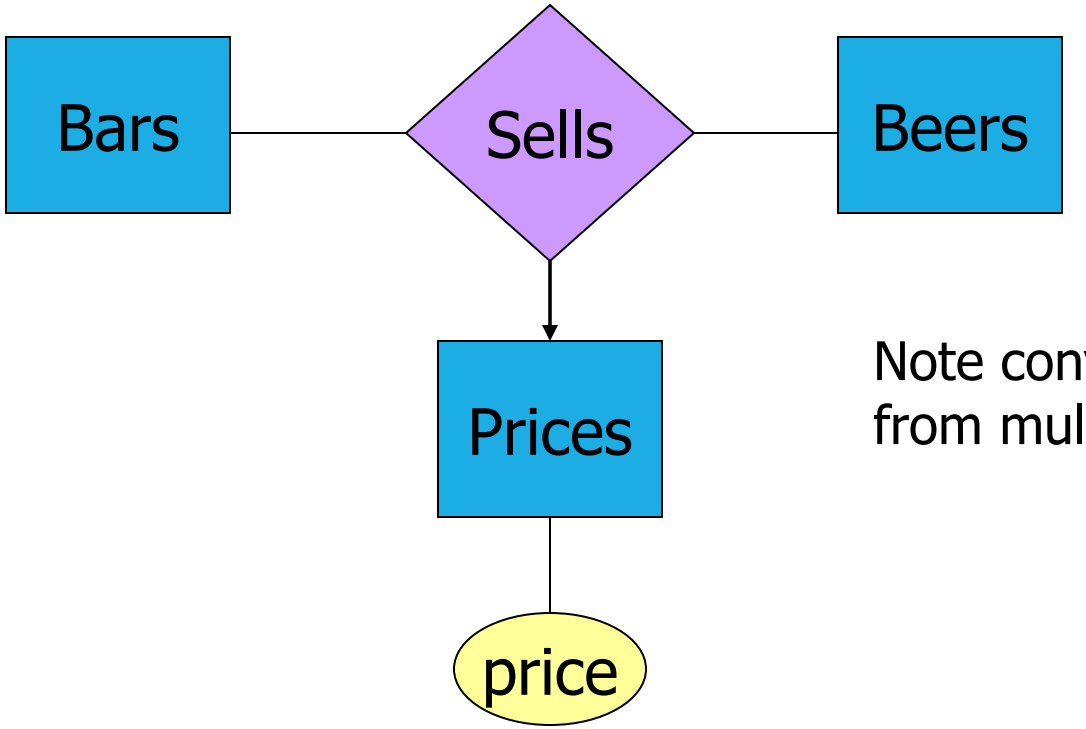
Price is a function of both the bar and the beer, not of one alone.

Equivalent Diagrams Without Attributes on Relationships

Create an entity set representing values of the attribute.

Make that entity set participate in the relationship.

Example: Removing an Attribute from a Relationship



Note convention: arrow from multiway relationship

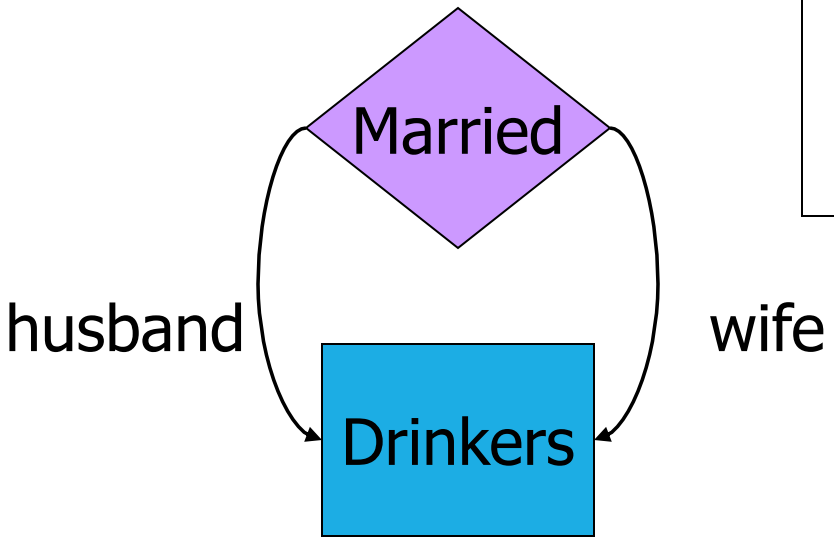
Roles

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*.

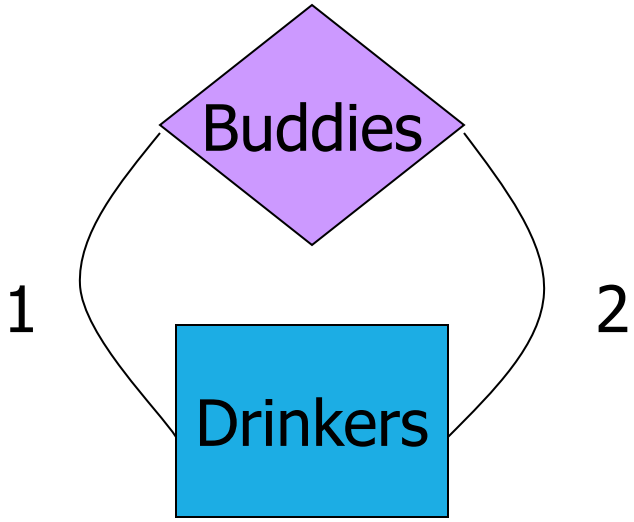
Example: Roles

Relationship Set



Husband	Wife
Bob	Ann
Joe	Sue
…	…

Example: Roles



Relationship Set

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

Subclasses

Subclass = special case = 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.

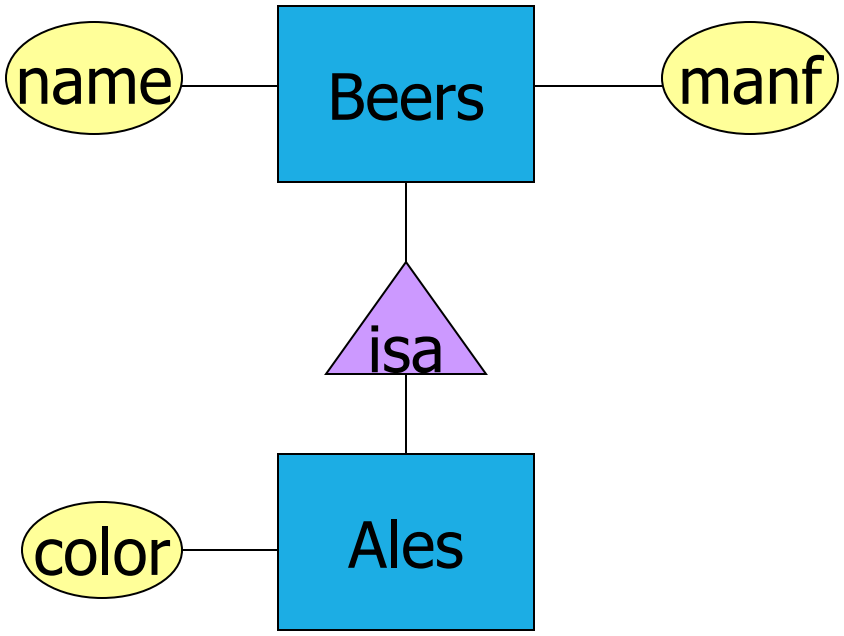
Subclasses in E/R Diagrams

Assume subclasses form a tree.

Isa triangles indicate the subclass relationship.

- Point to the superclass.

Example: Subclasses



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.

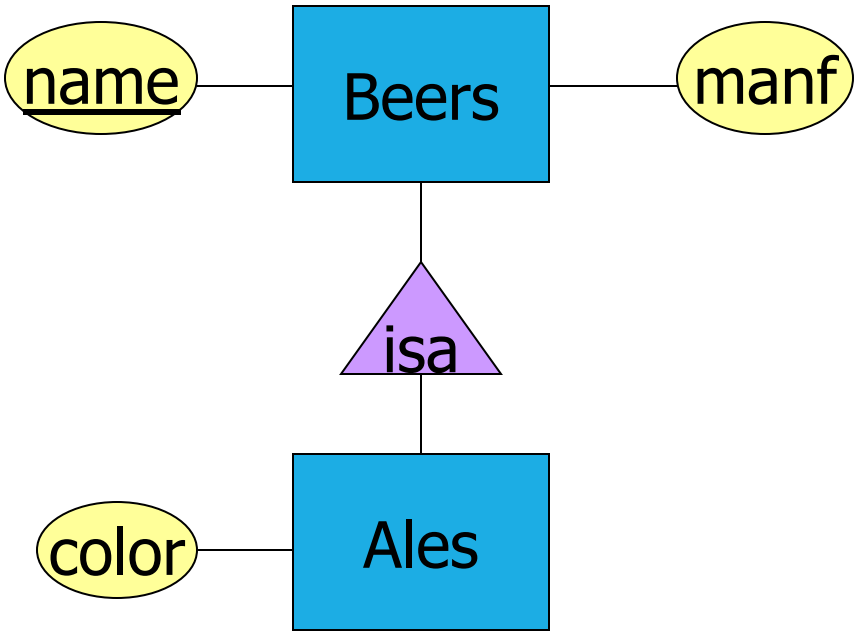
We must designate a key for every entity set.

Keys in E/R Diagrams

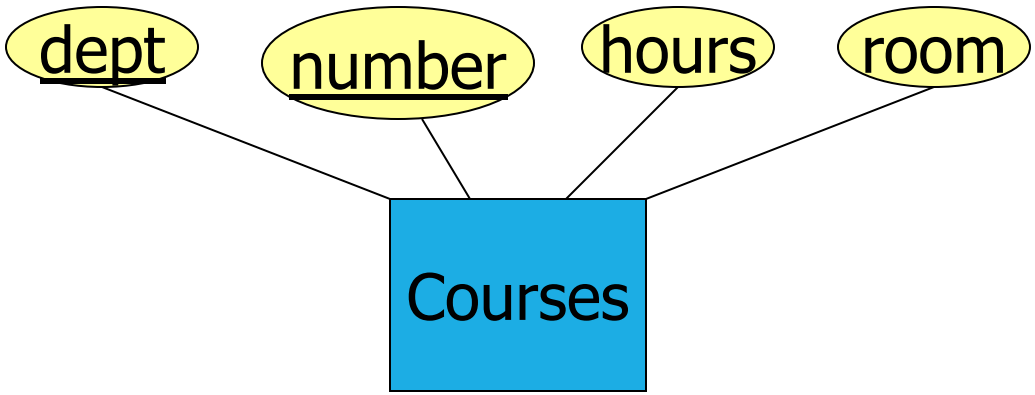
Underline the key attribute(s).

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.

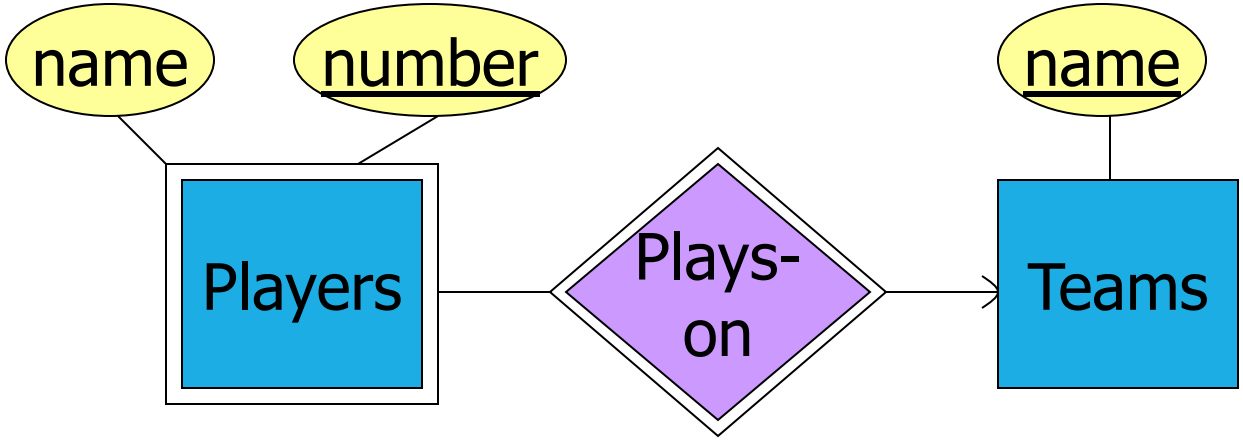
Example: Weak Entity Set

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



- 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).

Weak Entity-Set Rules – (2)

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. Do not use an entity set when an attribute will do.

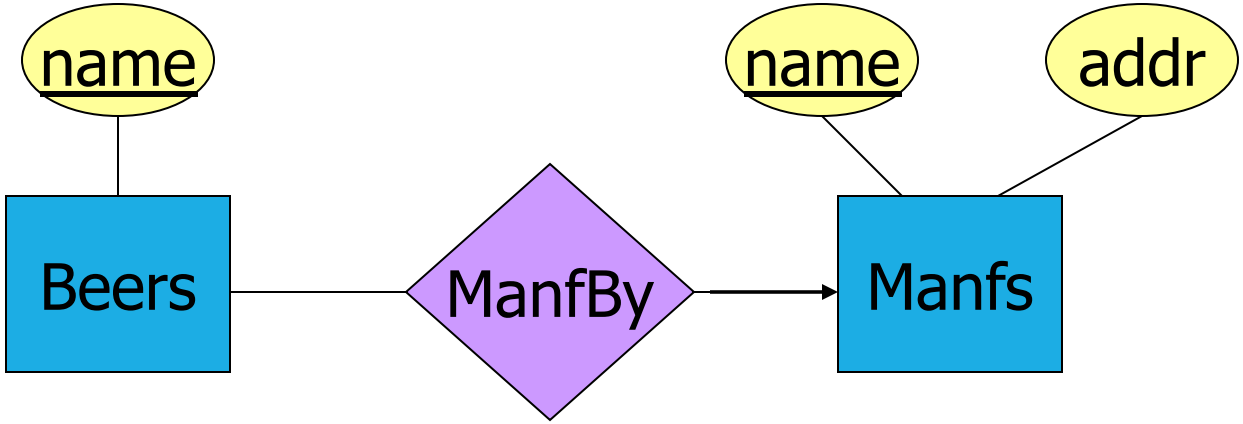
Avoiding Redundancy

Redundancy = saying the same thing in two (or more) different ways.

Wastes space and (more importantly) encourages inconsistency.

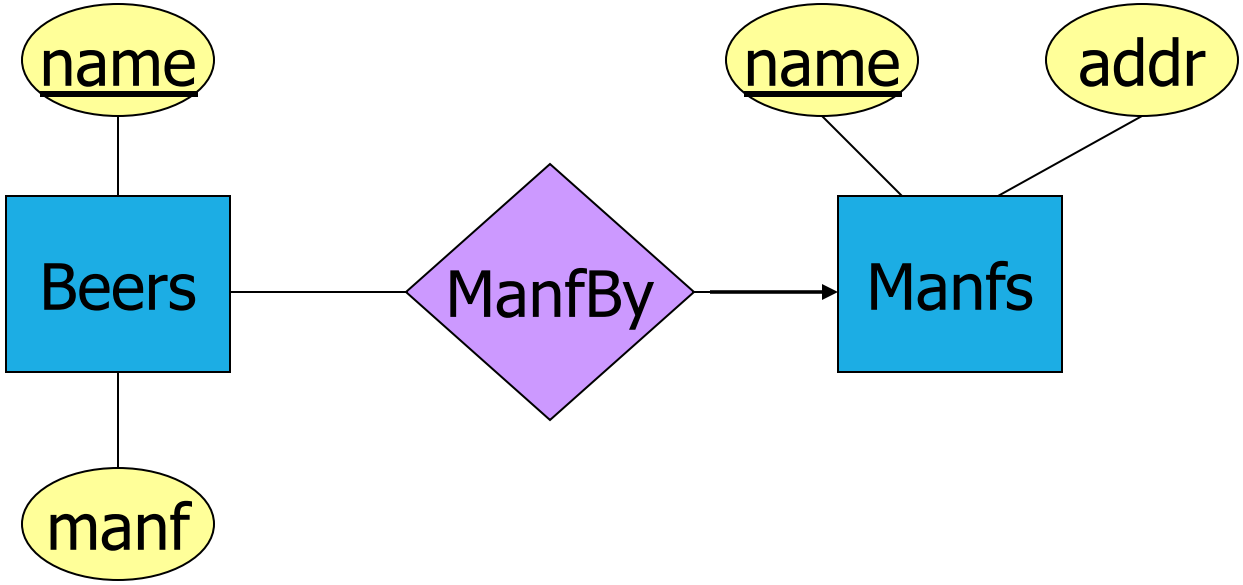
- Two representations of the same fact become inconsistent if we change one and forget to change the other.

Example: Good



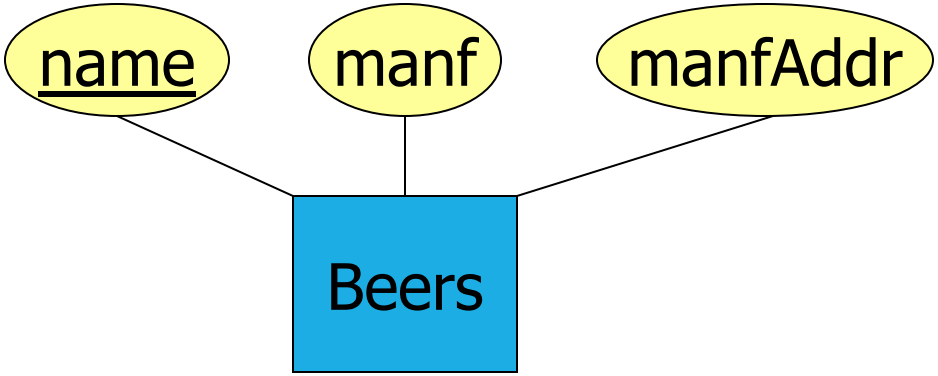
This design gives the address of each manufacturer exactly once.

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

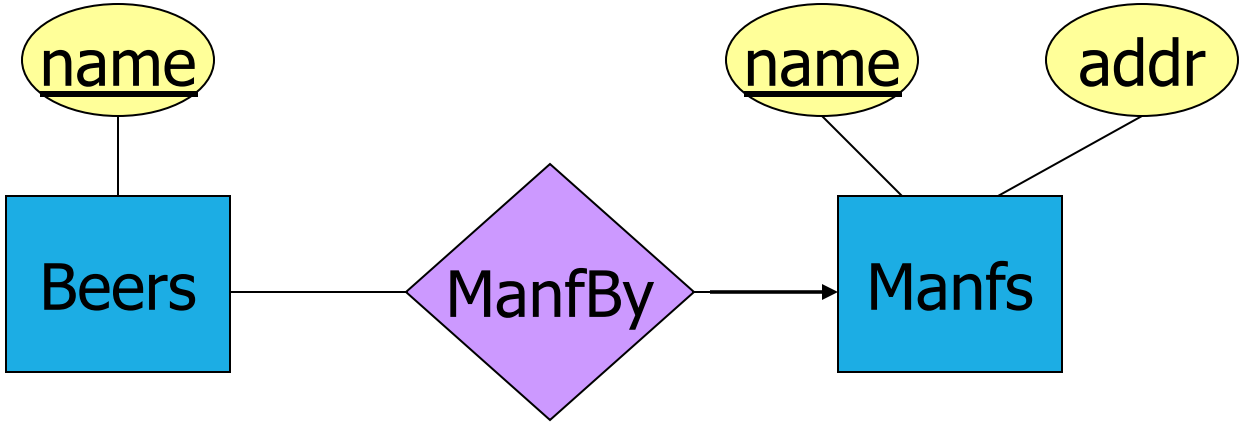
An entity set should satisfy at least one of the following conditions:

- It is more than the name of something; it has at least one nonkey attribute.

or

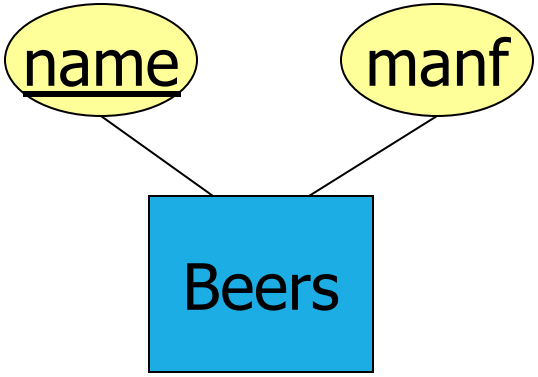
- It is the “many” in a many-one or many-many relationship.

Example: Good



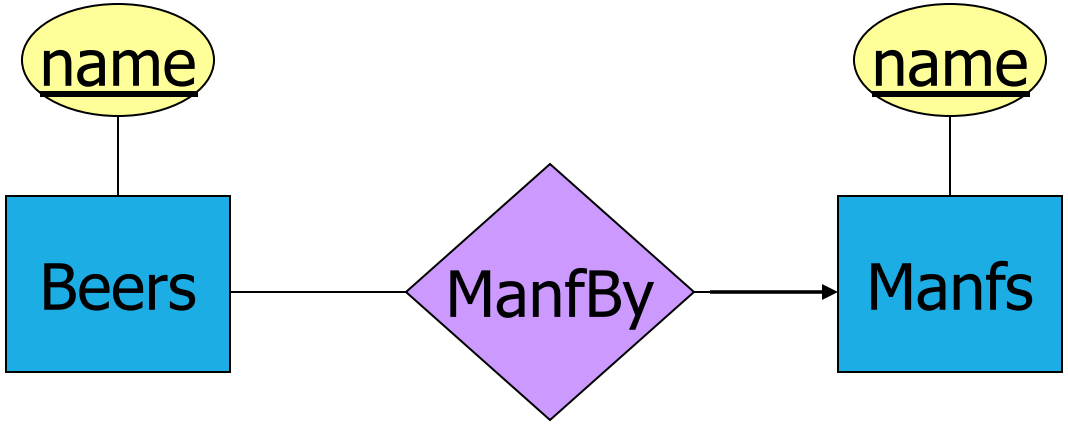
- Manfs deserves to be an entity set because of the nonkey attribute addr.
- Beers deserves to be an entity set because it is the "many" of the many-one relationship ManfBy.

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.

From E/R Diagrams to Relations

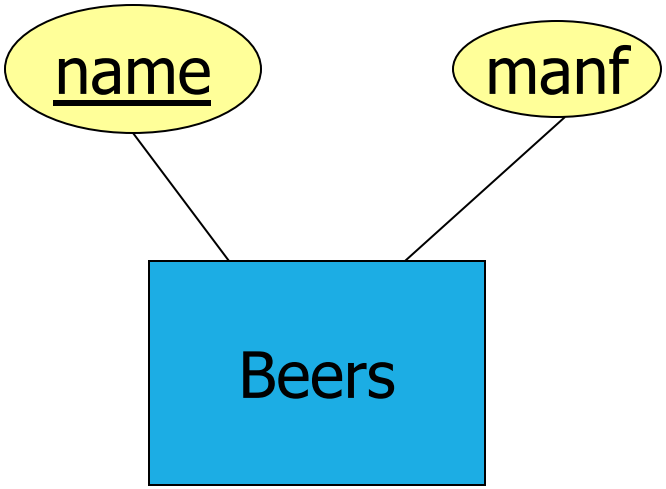
Entity set -> relation.

- Attributes -> attributes.

Relationships -> relations whose attributes are only:

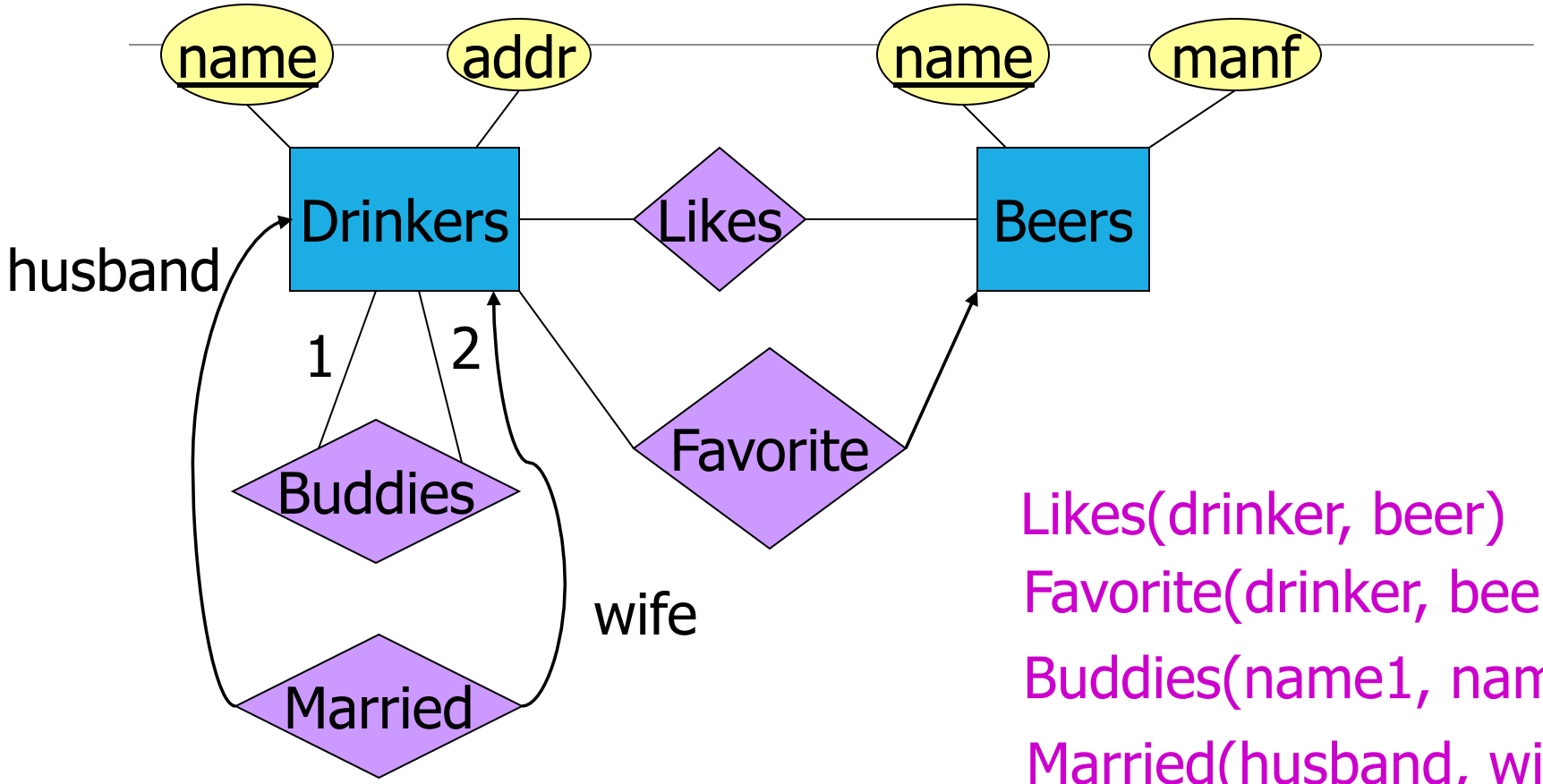
- The keys of the connected entity sets.
- Attributes of the relationship itself.

Entity Set -> Relation



Relation: Beers(name, manf)

Relationship -> Relation



Likes(drinker, beer)

Favorite(drinker, beer)

Buddies(name1, name2)

Married(husband, wife)

Combining Relations

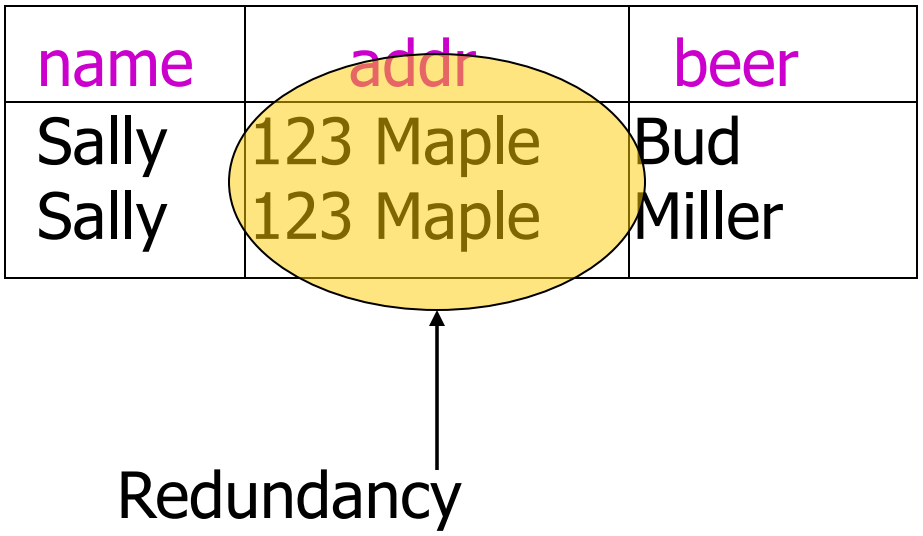
OK to combine into one relation:

1. The relation for an entity-set *E*
2. The relations for many-one relationships of which *E* is the "many."

Example: Drinkers(name, addr) and Favorite(drinker, beer) combine to make Drinker1(name, addr, favBeer).

Risk with Many-Many Relationships

Combining Drinkers with Likes would be a mistake. It leads to redundancy, as:

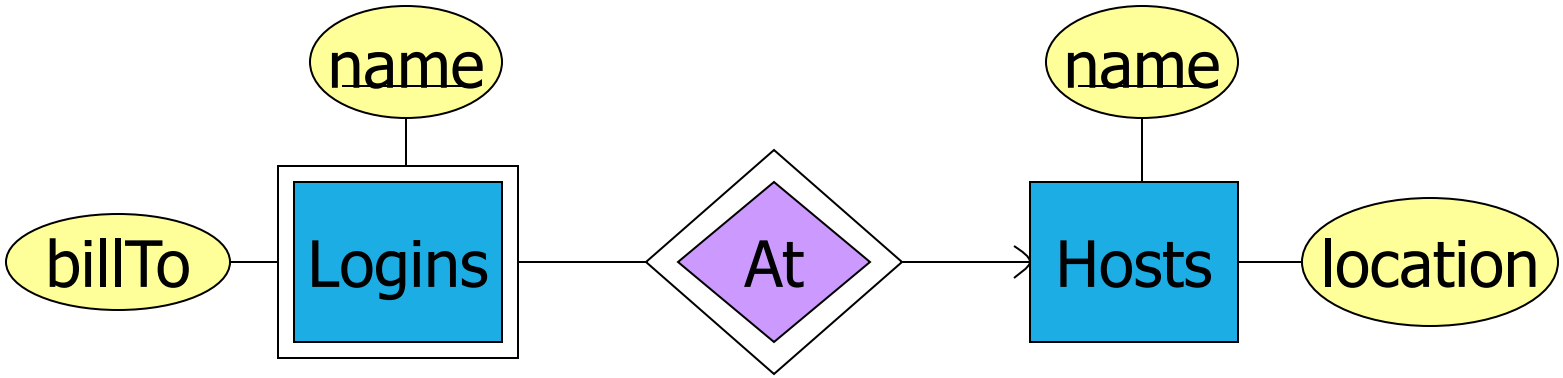


Handling Weak Entity Sets

Relation for a weak entity set must include attributes for its complete key (including those belonging to other entity sets), as well as its own, nonkey attributes.

A supporting relationship is redundant and yields no relation (unless *it* has attributes).

Example: Weak Entity Set -> Relation



Hosts(hostName, location)

Logins(loginName, hostName, billTo)

~~At(loginName, hostName, hostName2)~~

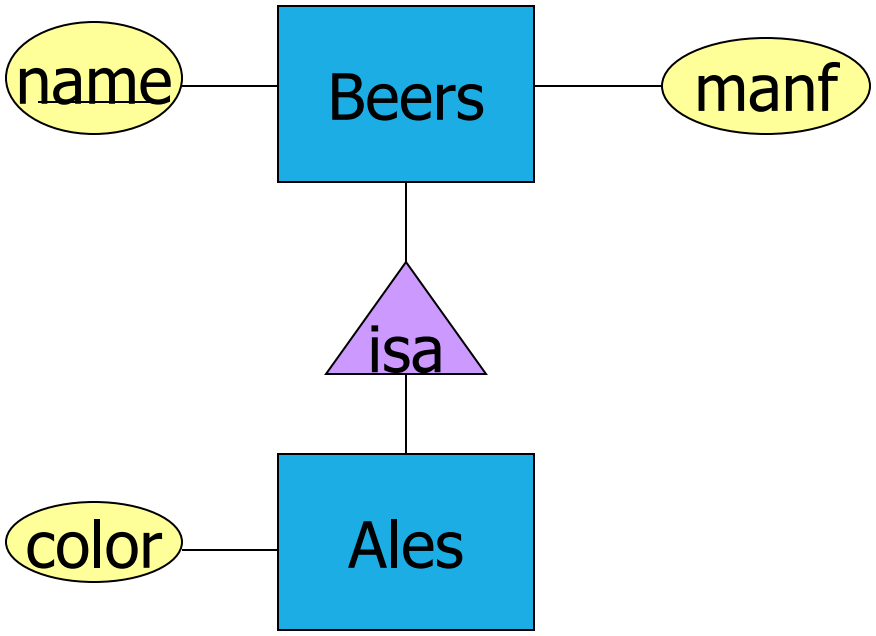
At becomes part of Logins

Must be the same

Subclasses: Three Approaches

1. *Object-oriented* : One relation per subset of subclasses, with all relevant attributes.
2. *Use nulls* : One relation; entities have NULL in attributes that don't belong to them.
3. *E/R style* : One relation for each subclass:
   - Key attribute(s).
   - Attributes of that subclass.

Example: Subclass -> Relations



Object-Oriented

name	manf
Bud	Anheuser-Busch

Beers

name	manf	color
Summerbrew	Pete's	dark

Ales

Good for queries like "find the color of ales made by Pete's."

E/R Style

name	manf
Bud	Anheuser-Busch
Summerbrew	Pete's

Beers

name	color
Summerbrew	dark

Ales

Good for queries like "find all beers (including ales) made by Pete's."

Using Nulls

name	manf	color
Bud	Anheuser-Busch	NULL
Summerbrew	Pete's	dark

Beers

Saves space unless there are *lots* of attributes that are usually NULL.

Conclusions and Actions!

- Conclusions
  - E/R Diagrams
- Control Questions
  - Many-many vs many-one
  - Weak Entity Set
  - Subclasses
- Actions
  - Review Slides
  - Read chapter about E/R model from course book (4.1-4.6)
  - Play with Toad Data Modeler!