

Entity-Relationship Model

Slides adapted from <http://infolab.stanford.edu/~ullman/fcdb.html>

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Purpose of E/R Model

- The E/R model allows us to sketch database schema designs.
 - Includes some constraints, but not operations.
- Designs are pictures called *entity-relationship diagrams*.
- **Later:** convert E/R designs to relational DB designs.

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Framework for E/R

- Design is a serious business.
- The “boss” knows they want a database, but they don’t know what they want in it.
- Sketching the key components is an efficient way to develop a working database.



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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, not structs, sets, etc.

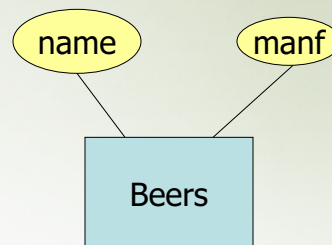
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E/R Diagrams

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

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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)

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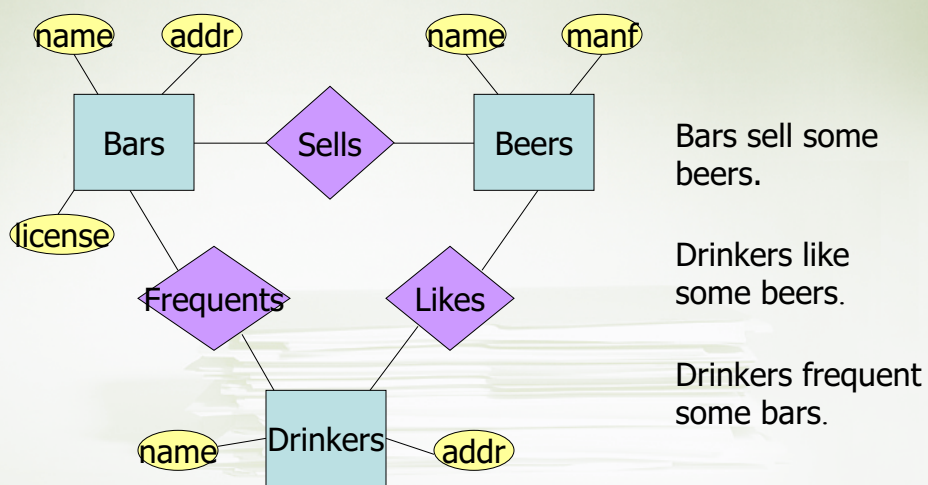
Beers(name, manf)
Bars(name, addr, license)
Drinkers(name, addr, phone)
Likes(drinker, beer)
Sells(bar, beer, price)
Frequents(drinker, bar)

Relationships

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

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Example: Relationships



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Beers(name, manf)
Bars(name, addr, license)
Drinkers(name, addr, phone)
Likes(drinker, beer)
Sells(bar, beer, price)
Frequents(drinker, bar)

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.

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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

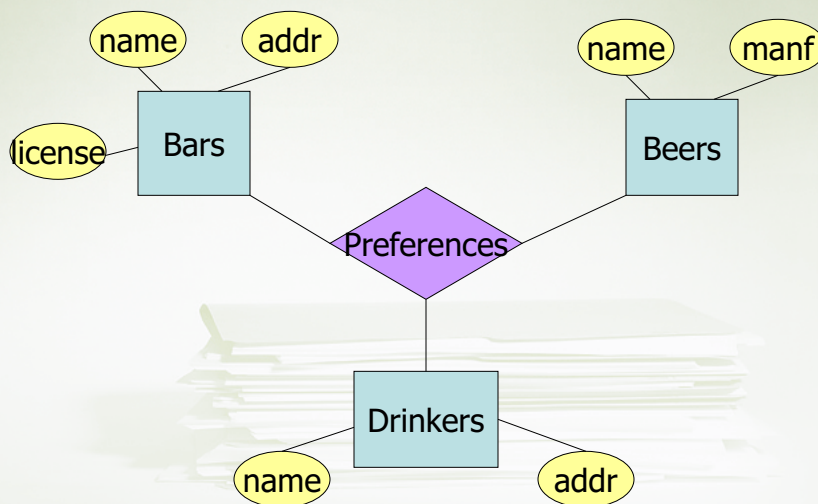
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Multiway Relationships

- 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.

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Example: 3-Way Relationship



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Beers(name, manf)
Bars(name, addr, license)
Drinkers(name, addr, phone)
Likes(drinker, beer)
Sells(bar, beer, price)
Frequents(drinker, bar)

A Sample 3-Way 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

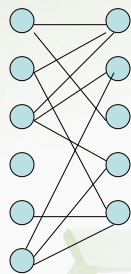
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Many-Many Relationships

- Cardinality of binary relationships: many-many, many-one, one-one
- 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.

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In Pictures:



many-many

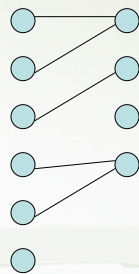
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Many-One Relationships

- 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.

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In Pictures:



many-one

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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.

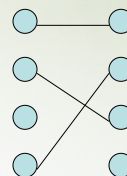
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One-One Relationships

- 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).

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In Pictures:



one-one

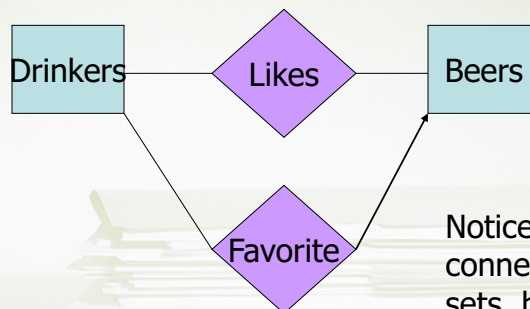
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Representing “Multiplicity”

- Show a many-one relationship by an arrow entering the “one” side.
 - **Remember:** Like a functional dependency.
- Show a one-one relationship by arrows entering both entity sets.

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Example: Many-One Relationship



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

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Beers(name, manf)
Bars(name, addr, license)
Drinkers(name, addr, phone)
Likes(drinker, beer)
Sells(bar, beer, price)
Frequents(drinker, bar)

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.

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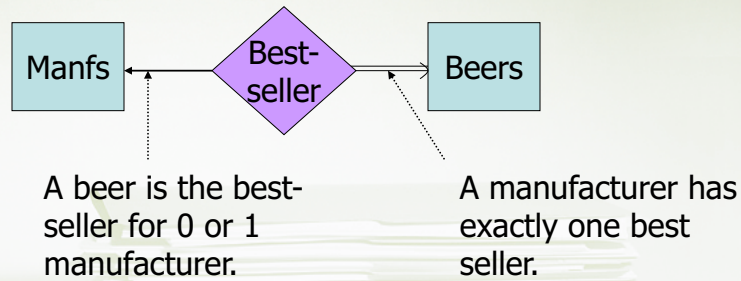
Participation

- The participation of an entity set E in a relationship set R is said to be **total** if every entity in E participates in at least one relationship in R.
 - Indicated by double lines
- If only some entities in E participate in relationships in R, the participation is said to be **partial**.

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Beers(name, manf)
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In the E/R Diagram



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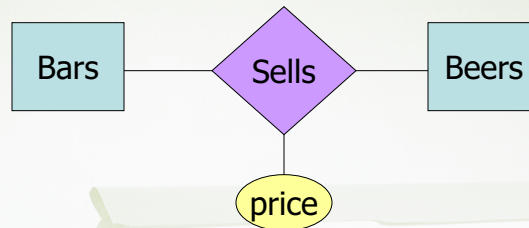
Attributes on Relationships

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

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Beers(name, manf)
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Sells(bar, beer, price)
Frequents(drinker, bar)

Example: Attribute on Relationship



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

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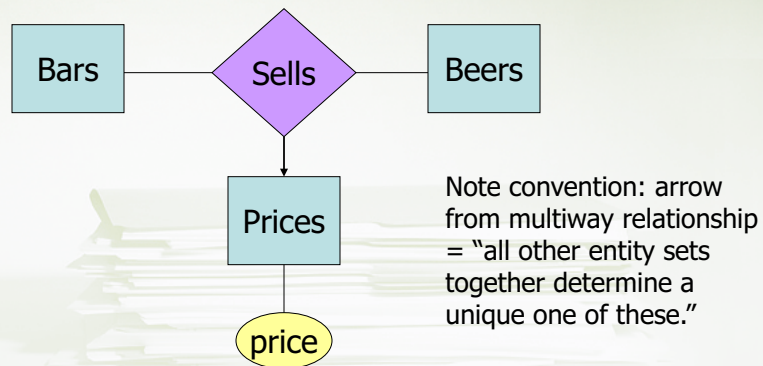
Equivalent Diagrams Without Attributes on Relationships

- Create an entity set representing values of the attribute.
 - Make that entity set participate in the relationship.
- The background of the slide shows a stack of books.

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Beers(name, manf)
Bars(name, addr, license)
Drinkers(name, addr, phone)
Likes(drinker, beer)
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Example: Removing an Attribute from a Relationship



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Roles

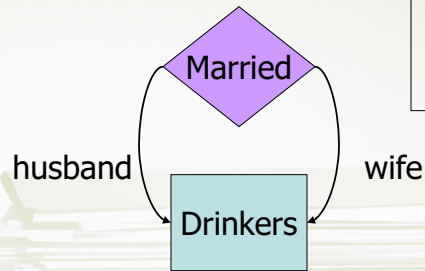
- Sometimes an entity set appears more than once in a relationship.
- Label the edges between the relationship and the entity set with names called *roles*.

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Example: Roles

Relationship Set

Husband	Wife
Bob	Ann
Joe	Sue
...	...



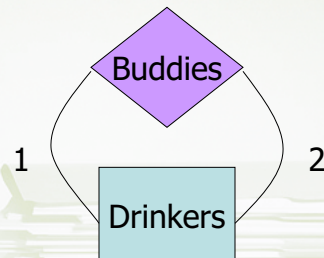
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Beers(name, manf)
Bars(name, addr, license)
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Example: Roles

Relationship Set

Buddy1	Buddy2
Bob	Ann
Joe	Sue
Ann	Bob
Joe	Moe
...	...



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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.

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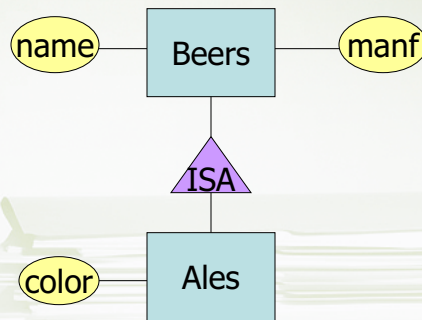
Subclasses in E/R Diagrams

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

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Beers(name, manf)
Bars(name, addr, license)
Drinkers(name, addr, phone)
Likes(drinker, beer)
Sells(bar, beer, price)
Frequents(drinker, bar)

Example: Subclasses



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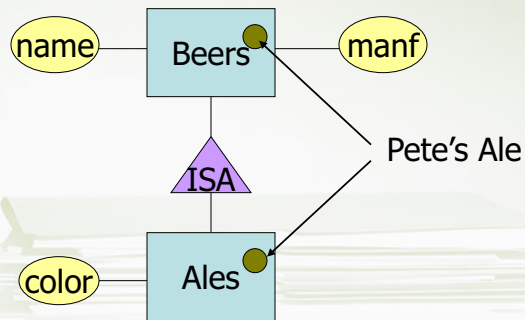
E/R Vs. Object-Oriented Subclasses

- In OOP, 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 (and recursively up the tree).

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Beers(name, manf)
Bars(name, addr, license)
Drinkers(name, addr, phone)
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Frequents(drinker, bar)

Example: Representatives of Entities



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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.

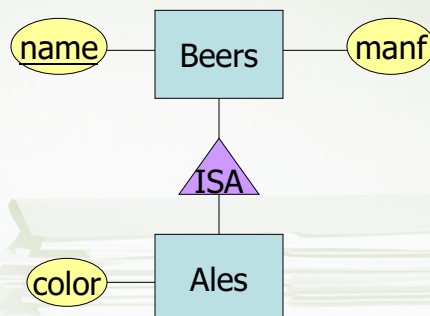
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Keys in E/R Diagrams

- 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.

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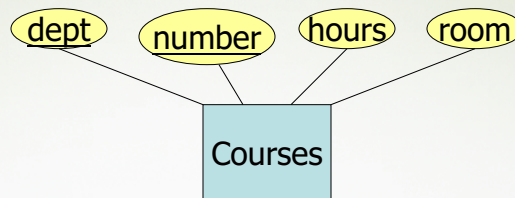
Example: **name** is Key for **Beers**



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Beers(name, manf)
Bars(name, addr, license)
Drinkers(name, addr, phone)
Likes(drinker, beer)
Sells(bar, beer, price)
Frequents(drinker, bar)

Example: a Multi-attribute Key



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

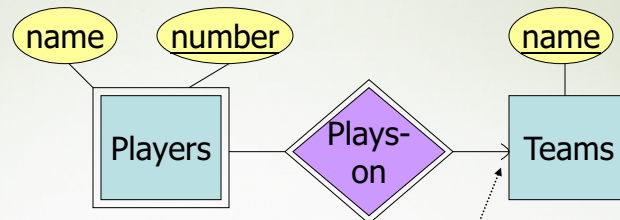
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Weak Entity Sets

- 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.

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Weak Entity Set 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.

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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.

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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).

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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.

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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.

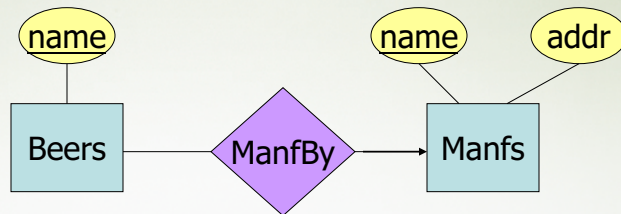
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Avoiding Redundancy

- **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.
 - Recall anomalies due to FD's.

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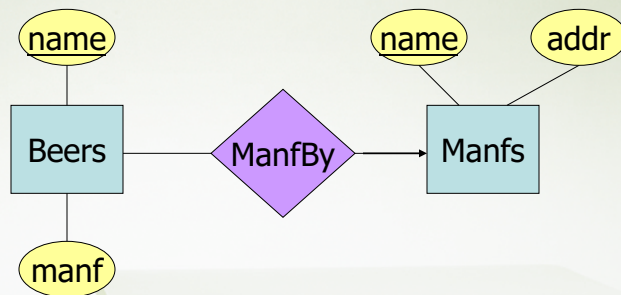
Example: Good



This design gives the address of each manufacturer exactly once.

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Example: Bad

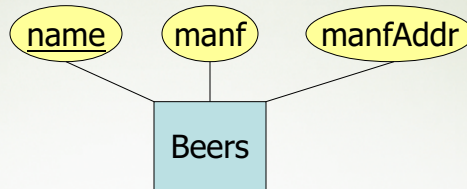


This design states the manufacturer of a beer twice: as an attribute and as a related entity.

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Beers(name, manf)
Bars(name, addr, license)
Drinkers(name, addr, phone)
Likes(drinker, beer)
Sells(bar, beer, price)
Frequents(drinker, bar)

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.

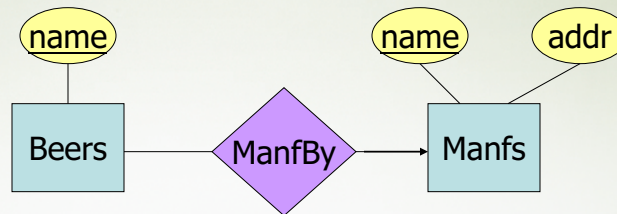
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Entity Sets Versus Attributes

- 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.

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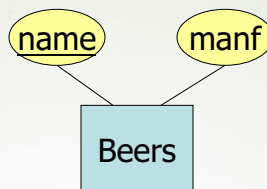
Example: Good



- **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**.

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Example: Good

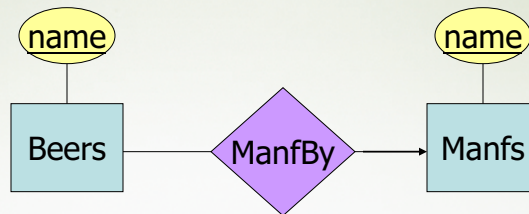


There is no need to make the manufacturer an entity set, because we record nothing about manufacturers besides their name.

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Beers(name, manf)
Bars(name, addr, license)
Drinkers(name, addr, phone)
Likes(drinker, beer)
Sells(bar, beer, price)
Frequents(drinker, bar)

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.

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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.

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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.

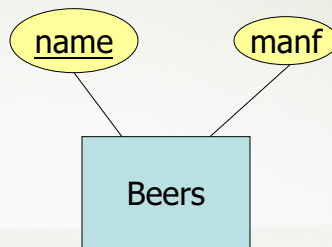
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From E/R Diagrams to Relations

- Entity set -> relation.
 - Attributes -> attributes.
- Relationships -> relations whose attributes are only:
 - The keys of the connected entity sets.
 - Attributes of the relationship itself.

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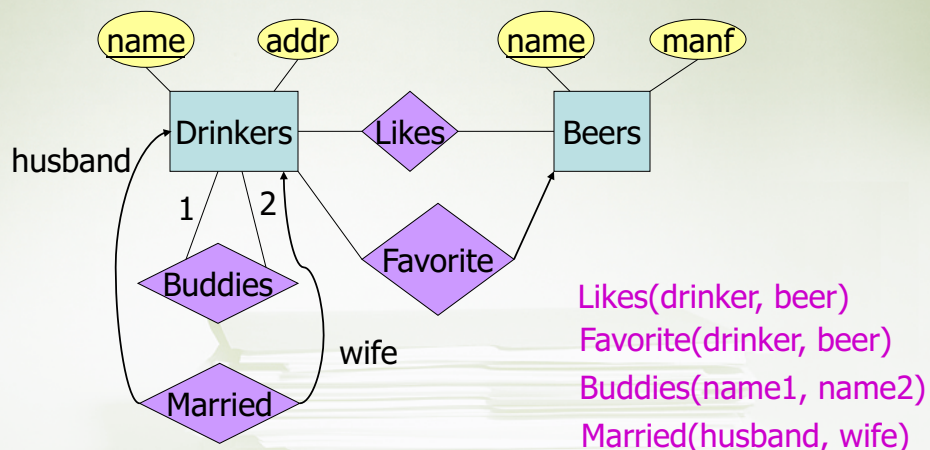
Entity Set -> Relation



Relation: **Beers(name, manf)**

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Relationship -> Relation



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Beers(name, manf)
 Bars(name, addr, license)
 Drinkers(name, addr, phone)
 Likes(drinker, beer)
 Sells(bar, beer, price)
 Frequents(drinker, bar)

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).

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Risk with Many-Many Relationships

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

name	addr	beer
Sally	123 Maple	Bud
Sally	123 Maple	Miller

Redundancy

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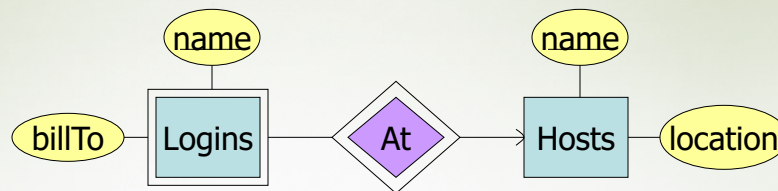
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Handling Weak Entity Sets

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

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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

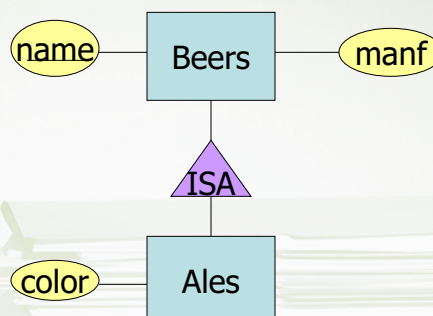
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Subclasses: Three Approaches

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.

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Example: Subclass -> Relations



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Bars(name, addr, license)
Drinkers(name, addr, phone)
Likes(drinker, beer)
Sells(bar, beer, price)
Frequents(drinker, bar)

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."

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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."

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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.

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