Relational Model

INF 551

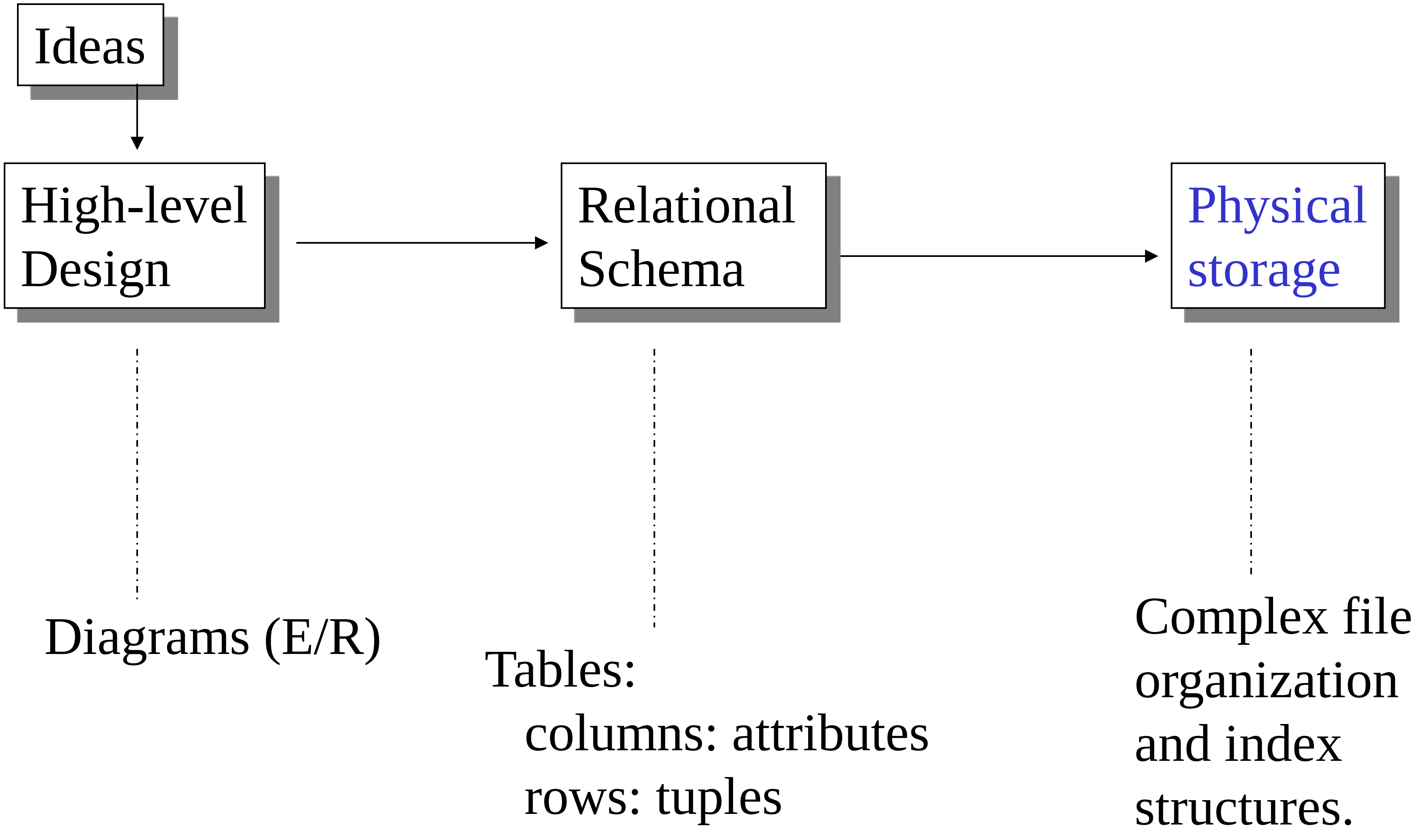
Wensheng Wu

Lecture Outline

- Relational model
- Translating ER into relational model

Motivations & comparison of ER with relational model ...

Database Modeling & Implementation



ER Model vs. Relational Model

- Both are used to model data
- ER model has many concepts
  - entities, relationships, is-a, etc.
  - well-suited for capturing the app. requirements
  - not well-suited for computer implementation
- Relational model
  - has just a single concept: relation
  - world is represented with a collection of tables
  - well-suited for efficient manipulations on computers

The basics of the relational model ...

An Example of a Relation

Table/relation name

Attribute names

Products:

Name	Price	Category	Manufacturer
gizmo	$19.99	gadgets	GizmoWorks
Power gizmo	$29.99	gadgets	GizmoWorks
SingleTouch	$149.99	photography	Canon
MultiTouch	$203.99	household	Hitachi

tuples

Domains

- Each attribute has a type
- Must be atomic type
- Called *domain*
- Examples:
  - Integer
  - String
  - Real
  - ...

Schemas vs. instances (very important, make sure you know the difference)

Schemas

Schema: describe the structure of data

The Schema of a Relation:

- Relation name plus attribute names
- E.g. Product(Name, Price, Category, Manufacturer)
- In practice we add the domain for each attribute

The Schema of a Database

- A set of relational schemas
- E.g. Product(Name, Price, Category, Manufacturer),
  Vendor(Name, Address, Phone),
  . . . .

Instances

Schema instance = data

- **Relational schema** = R(A1, ..., Ak):
  Instance = relation (of "type" R) with a collection of tuples
  - Each has k values from the domains of their corresponding attributes

- **Database schema** = R1(...), R2(...), ..., Rn(...)
  Instance = n relations, of types R1, R2, ..., Rn

Example

Relational schema: Product(Name, Price, Category, Manufacturer)
Instance:

Name	Price	Category	Manufacturer
gizmo	$19.99	gadgets	GizmoWorks
Power gizmo	$29.99	gadgets	GizmoWorks
SingleTouch	$149.99	photography	Canon
MultiTouch	$203.99	household	Hitachi

Updates

The database maintains a current database state.

Updates to the data:

1) add a tuple
2) delete a tuple
3) modify the values of some attributes in a tuple

Updates to the data happen very frequently.

Updates to the schema: relatively rare. Rather painful. Why**?**

Schemas and Instances

- Analogy with programming languages:
  - Schema = type/class
  - Instance = value/instance
- Important distinction:
  - Database Schema = stable over long periods of time
  - Database Instance = changes constantly, as data is inserted/updated/deleted

How should we talk about relations (that is, represent them)?

Two Mathematical Definitions of Relations

Product(Name, Price, Category, Manufacturer)

Relation as a subset of Cartesian product

- Tuple = element of **string** x **int** x **string** x **string**
- E.g. t = ("gizmo", 19, "gadgets", "GizmoWorks")
- Relation = subset of **string** x **int** x **string** x **string**
- Order in the tuple is important!
  - ("gizmo", 19, "gadgets", "GizmoWorks")
  - ("gizmo", 19, "GizmoWorks", "gadgets")
- No (explicit) attributes (in tuple expression)

Relation as a set of functions

- Fix the set of attributes
  - A={name, price, category, manufacturer}
- A tuple = function t: A $\rightarrow$ attribute domains
- Relation = a set of tuples/functions

- E.g. t(name) = "gizmo", t(price) = 19, t(category) = "gadgets", t(manufacturer) = "GizmoWorks"

- Order in a tuple is not important
- Attribute names are important

Examples of Insert

- Positional tuples, without specifying attribute names
  - E.g., insert into Employee values (123, 'john', 35, 'los angeles)

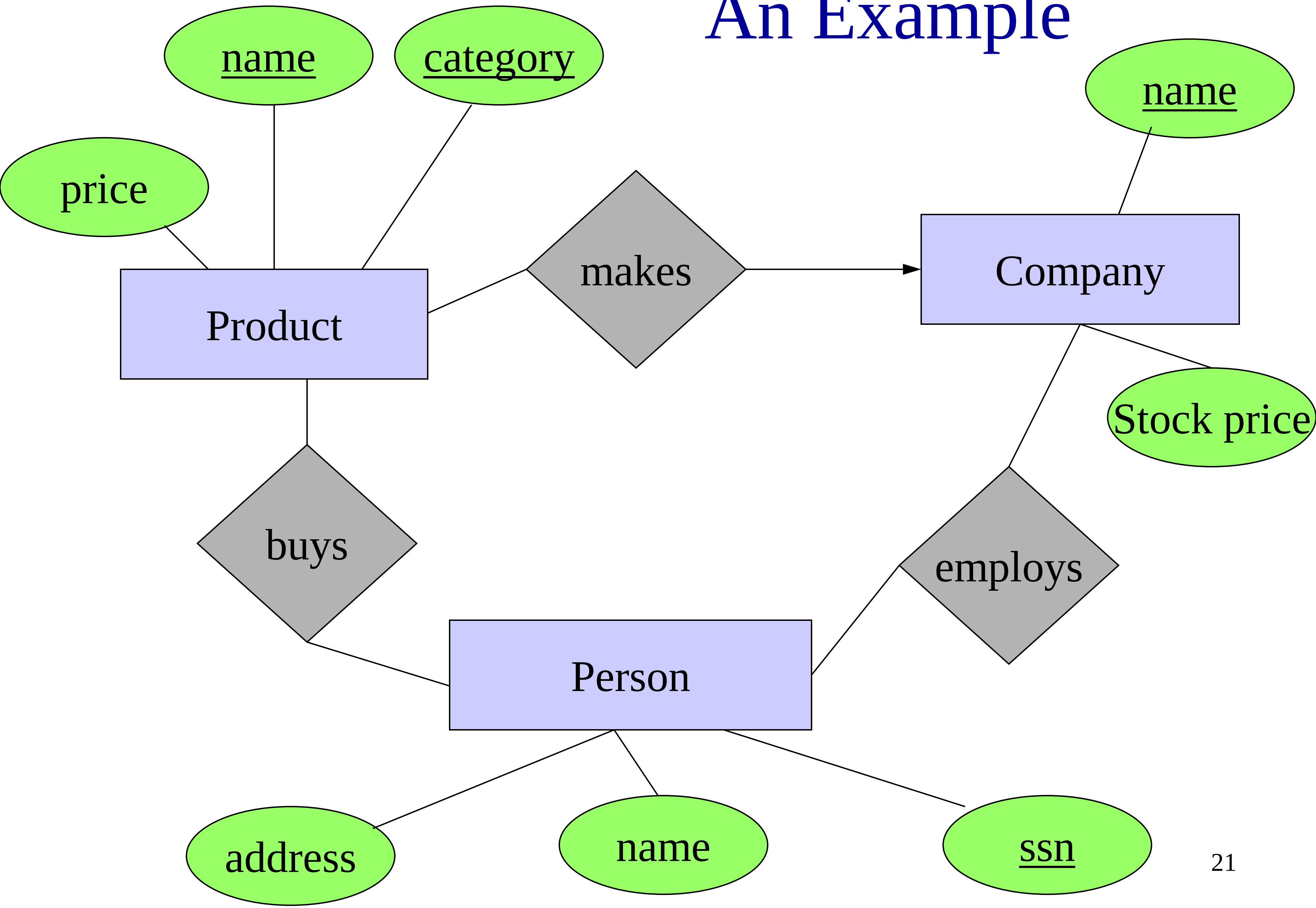
- Relational schemas with attribute names
  - E.g., insert into Employee(id, name) values (123, 'john')

Now the fun part: translating from ER to relational model

Translating ER Diagram to Rel. Model

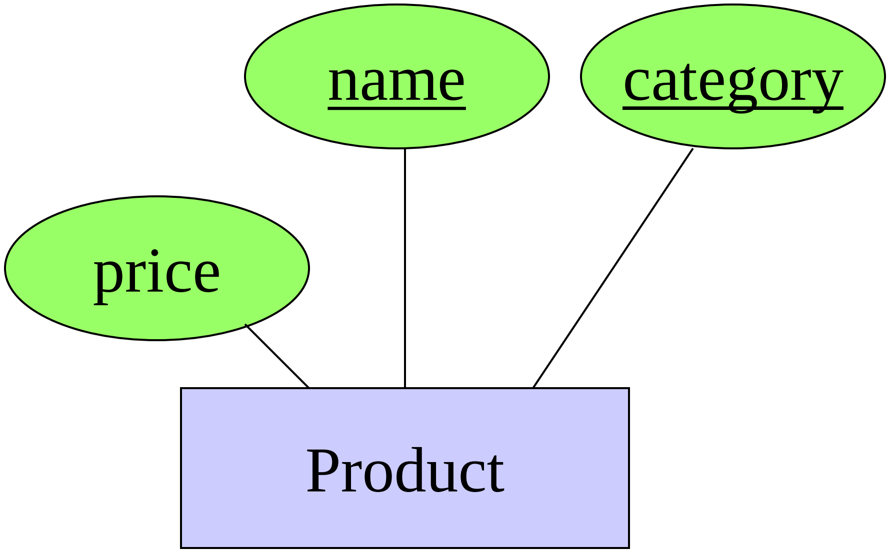
- Basic cases
  - entity set E => relation with attributes of E
  - relationship R => relation with attributes being keys of related entity sets + attributes of R
- Special cases
  - combining two relations
  - translating weak entity sets
  - translating is-a relationships and subclasses

An Example


name
category
price
name
Product
makes
Company
Stock price
buys
employs
Person
address
name
ssn

Basic cases ...

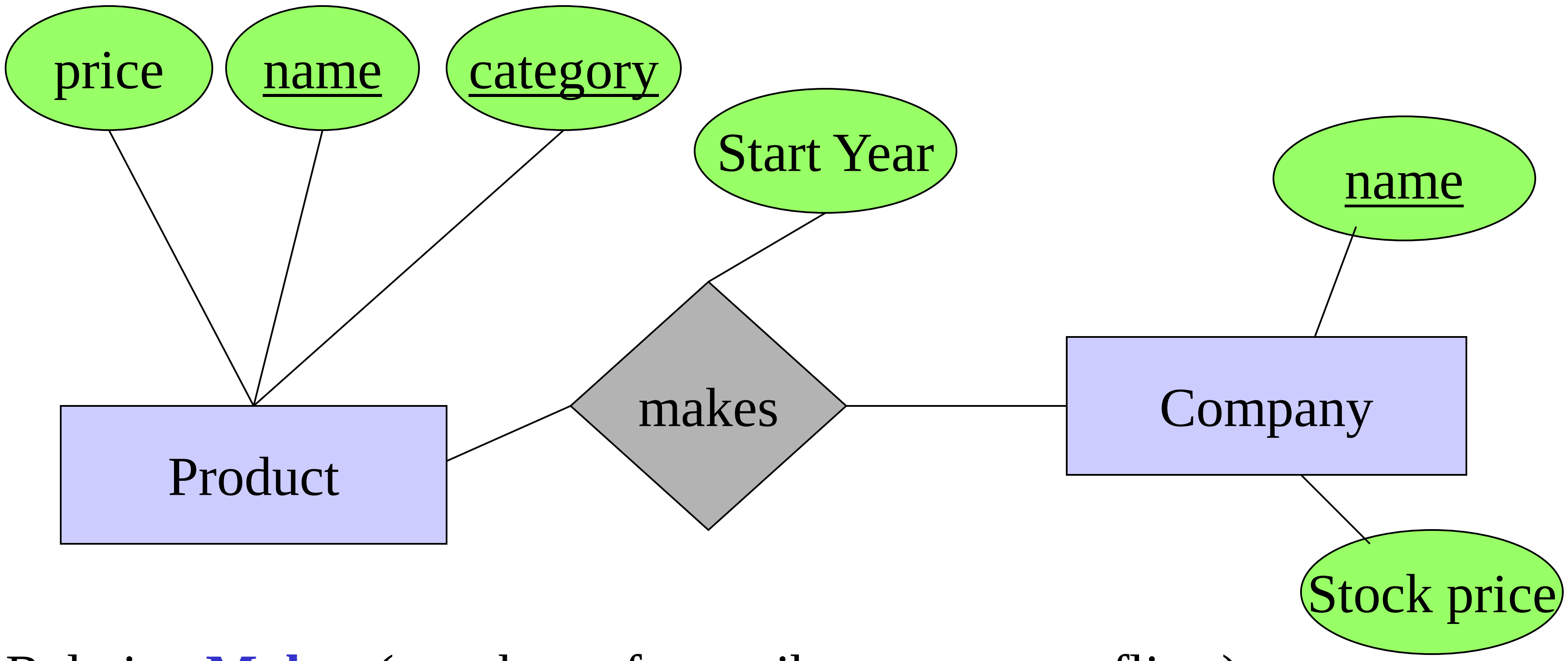
Entity Sets to Relations



Product:

Name	Category	Price
gizmo	gadgets	$19.99

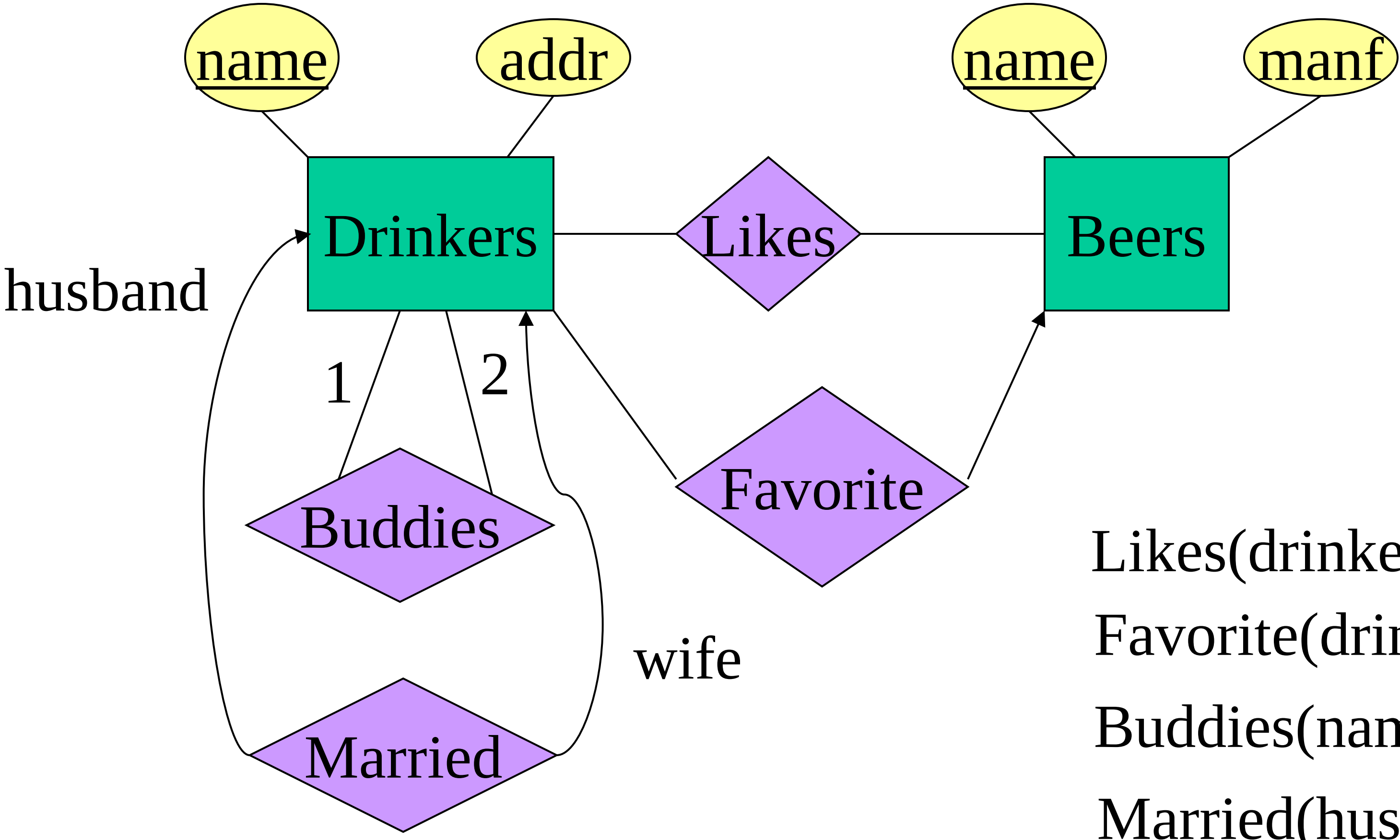
Relationships to Relations



Relation **Makes** (watch out for attribute name conflicts)

Product-name	Product-Category	Company-name	Starting-year
gizmo	gadgets	gizmoWorks	1963

Relationship to Relation: Another Example



Likes(drinker, beer)

Favorite(drinker, beer)

Buddies(name1, name2)

Married(husband, wife)

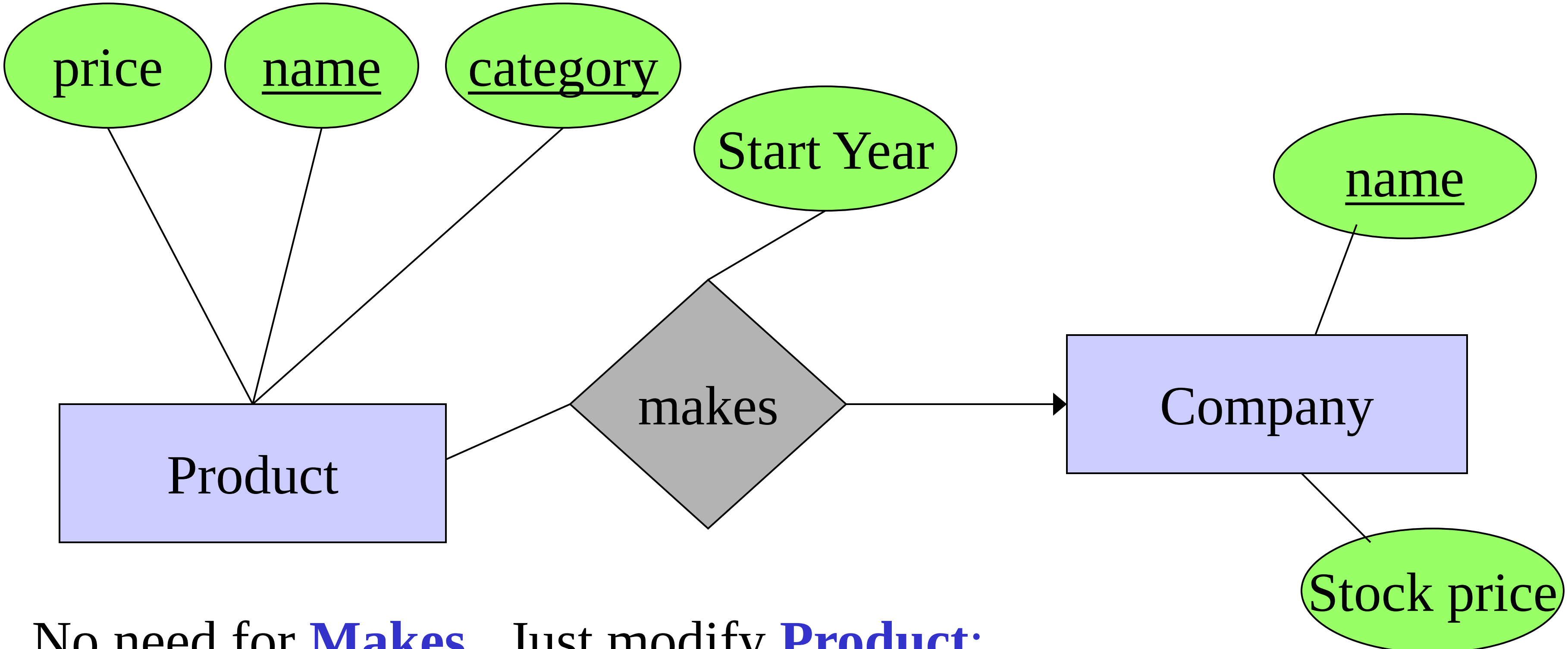
Special cases:

1) many-one relations

2) weak entity sets

3) is-a cases

Combining Two Relations

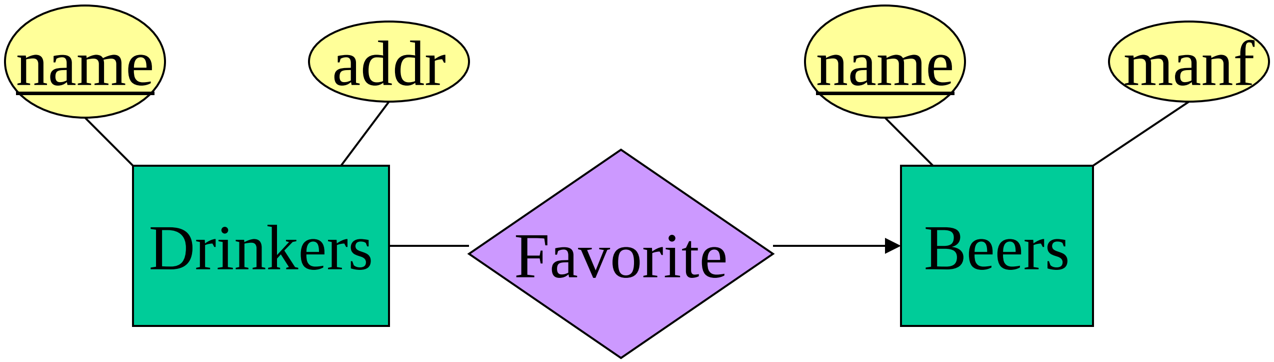


No need for **Makes**. Just modify **Product**:

name	category	price	StartYear	companyName
gizmo	gadgets	19.99	1963	gizmoWorks

Combining Relations

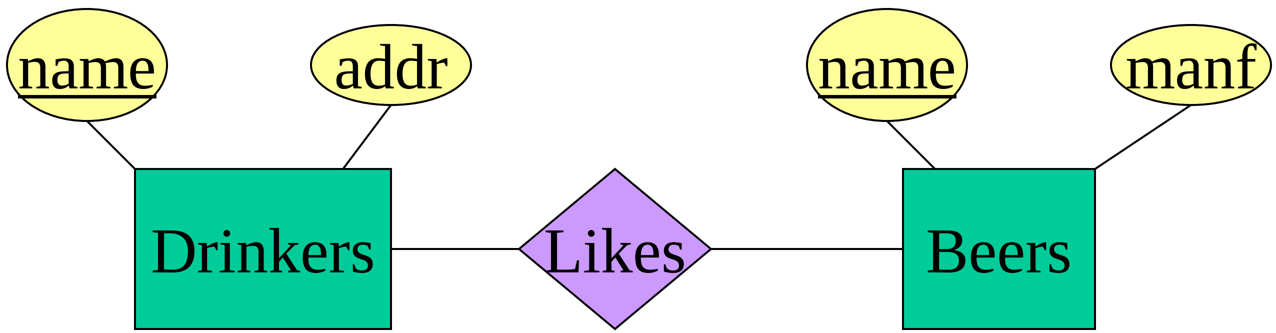
- Combine relation for an m-1 relationship R with the relation for the entity set on the many side of R



- Example: combine Drinkers(name, addr) and Favorite(drinker, beer) => Drinkers(name, addr, favoriteBeer).
  - But any drawback from doing this?

Risk with Many-Many Relationships

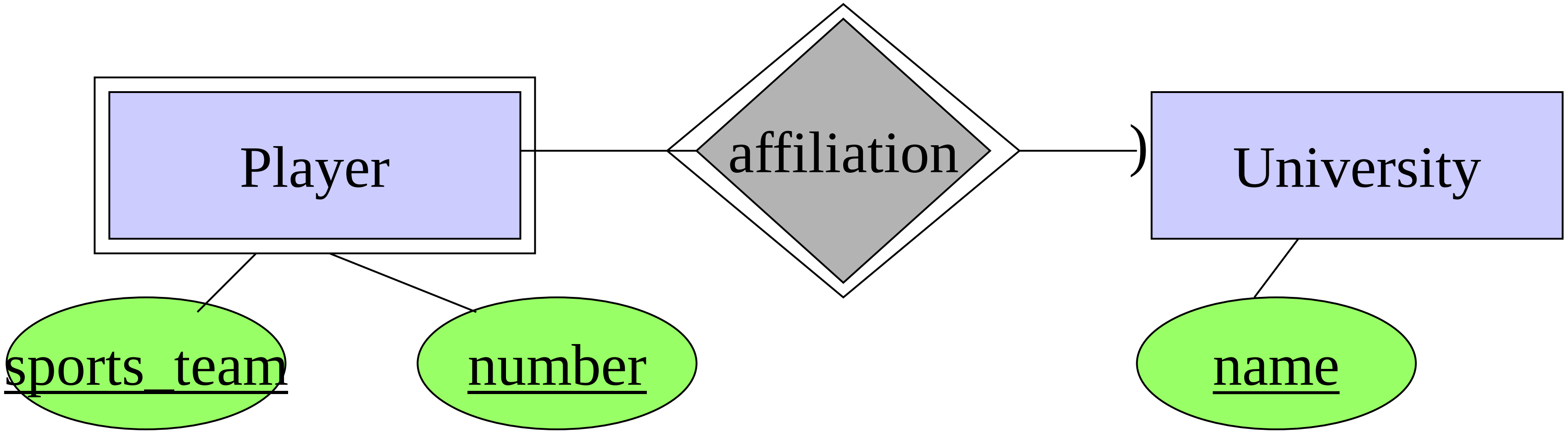
- Combining Drinkers with Likes would be a mistake. It leads to redundancy, as:



name	addr	beer
Sally	123 Maple	Bud
Sally	123 Maple	Miller

Redundancy

Handling Weak Entity Sets



Relation Player:

SportTeam	Number	Affiliated University
Trojan	15	USC

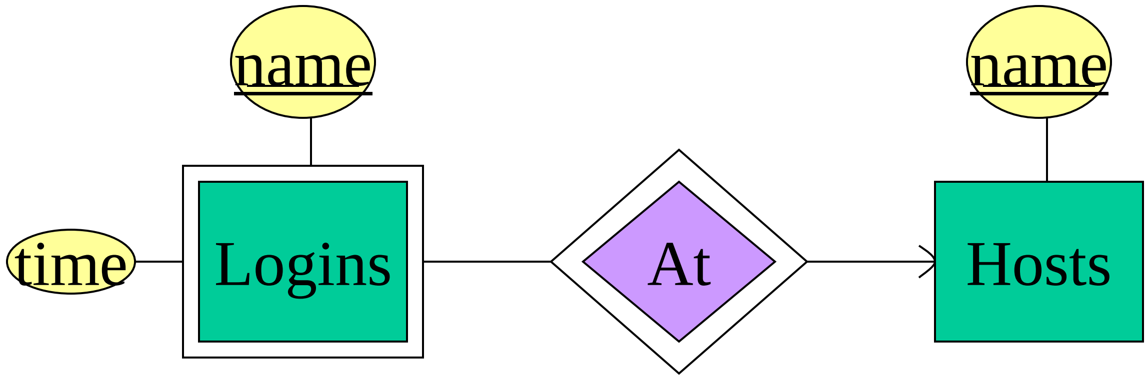
- need all the attributes that contribute to the key of Player
- don't need a separate relation for Affiliation. (why ?)

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 (double-diamond) relationship is redundant and yields no relation.

Another Example



Hosts(hostName)

Logins(loginName, hostName, time)

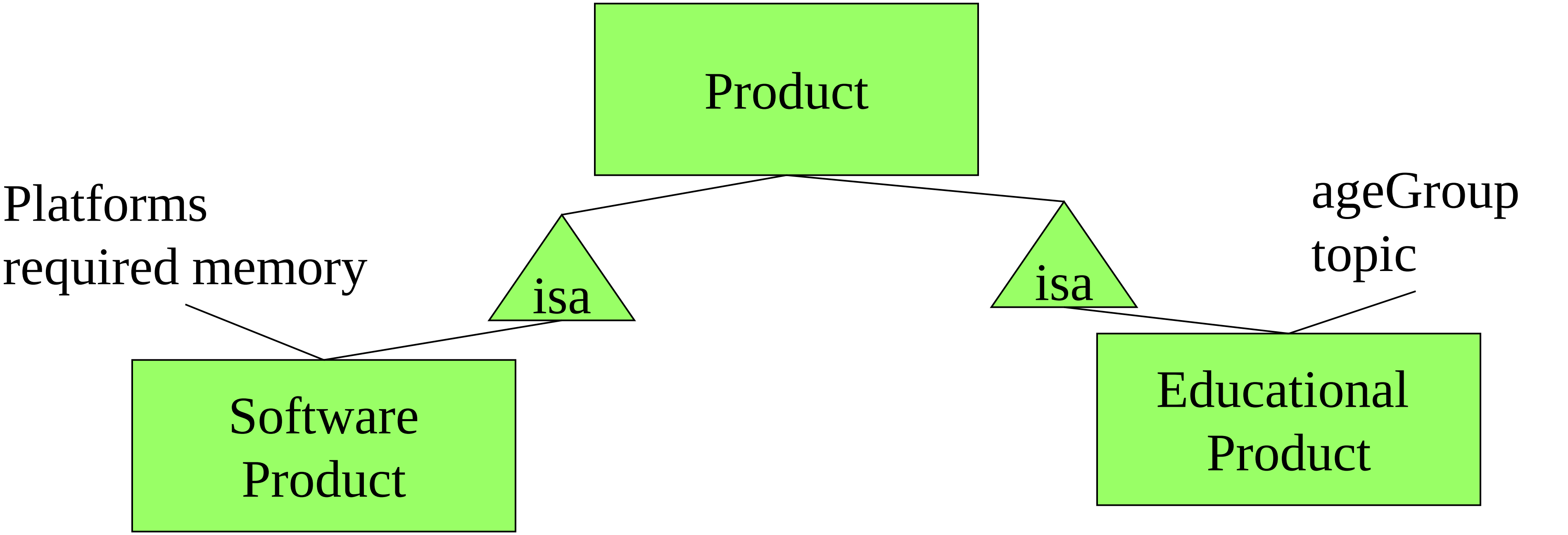
~~At(loginName, hostName, hostName2)~~

Must be the same

At becomes part of Logins

Translating Subclass Entities

Product(<u>name</u>, price, category, manufacturer)



Option #1: the OO Approach

4 tables: each object can only belong to a single table

One table for each subtree rooted at Product

Product(<u>name</u>, price, category, manufacturer)

EducationalProduct(<u>name</u>, price, category, manufacturer,
ageGroup, topic)

SoftwareProduct(<u>name</u>, price, category, manufacturer,
platforms, requiredMemory)

EducationalSoftwareProduct(<u>name</u>, price, category, manufacturer,
ageGroup, topic,
platforms, requiredMemory)

(Values of) all <u>names</u> in different tables are distinct

Option #2: the E/R Approach

Product(name, price, category, manufacturer)

EducationalProduct(name, ageGroup, topic)

SoftwareProduct(name, platforms, requiredMemory)

No need for a relation EducationalSoftwareProduct

The same name value (i.e., product) may appear in several relations

Option #3: The Null Value Approach

Has one table:

Product (name, price, category,
manufacturer, age-group, topic, platforms,
required-memory)

Some values in the table will be NULL, meaning that the attribute does not make sense for the specific product.

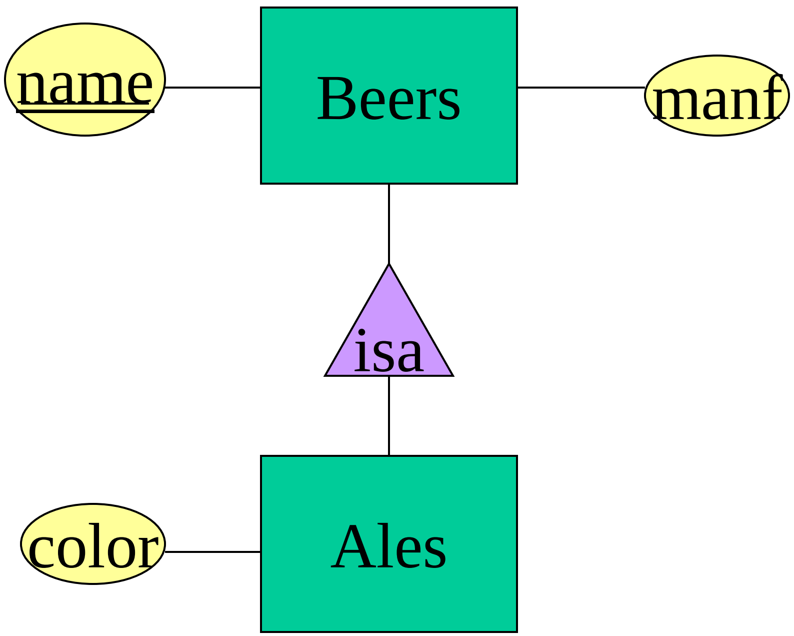
Problem: too many NULLs

Translating Subclass Entities: The Rules

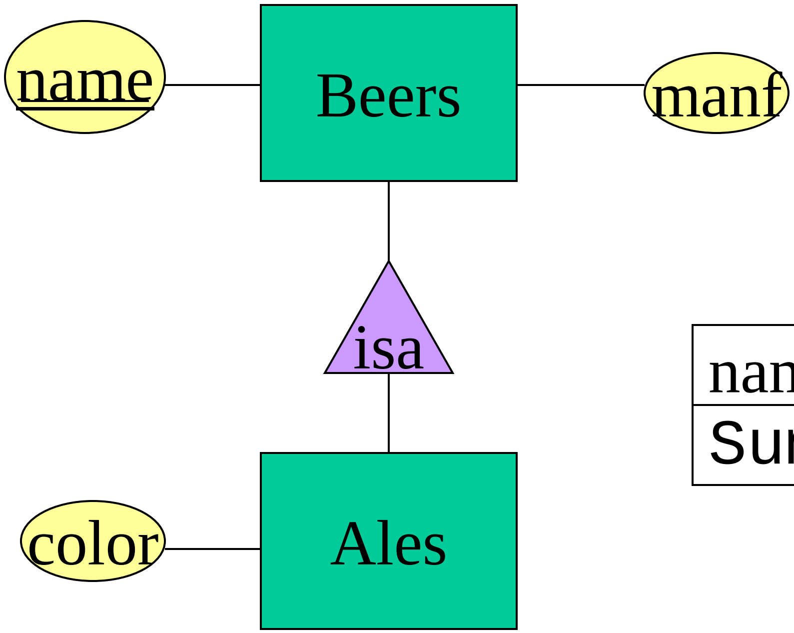
Three approaches:

1. *Object-oriented* : each entity belongs to exactly one class; create a relation for each possible subtree including the root, with all its attributes.
2. *E/R style* : create one relation for each subclass, with only the key attribute(s) and attributes attached to that entity set.
3. *Use nulls* : create one relation; entities have null in attributes that don't belong to them.

Example



Object-Oriented



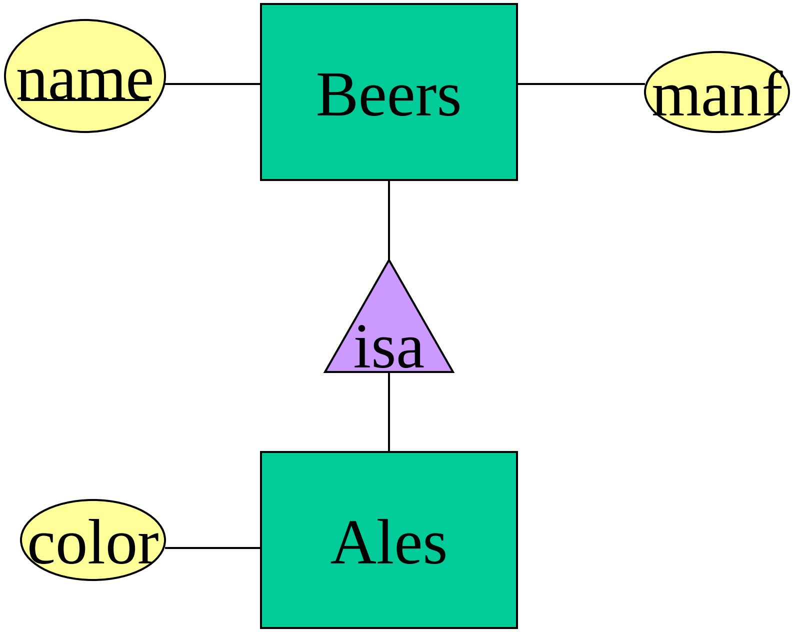
name	manf
Bud	Anheuser-Busch

Beers

name	manf	color
Summerbrew	Pete's	dark

Ales

E/R Style



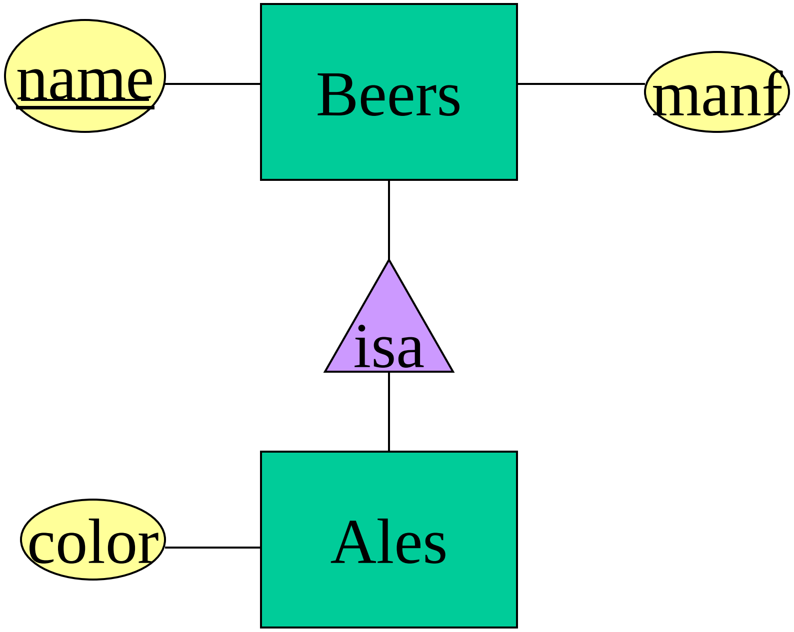
name	manf
Bud	Anheuser-Busch
Summerbrew	Pete's

Beers

name	color
Summerbrew	dark

Ales

Using Nulls



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

Beers

Comparisons

- O-O approach good for queries like "find the color of ales made by Pete's."
  - Just look in Ales relation.
- E/R approach good for queries like "find all beers (including ales) made by Pete's."
  - Just look in Beers relation.
- Using nulls might waste space if there are *lots* of attributes that are usually null.

Mixed-Type Inheritance in PostgreSQL

- CREATE TABLE cities

  (<u>name</u> text, population real, altitude int);
- CREATE TABLE capitals

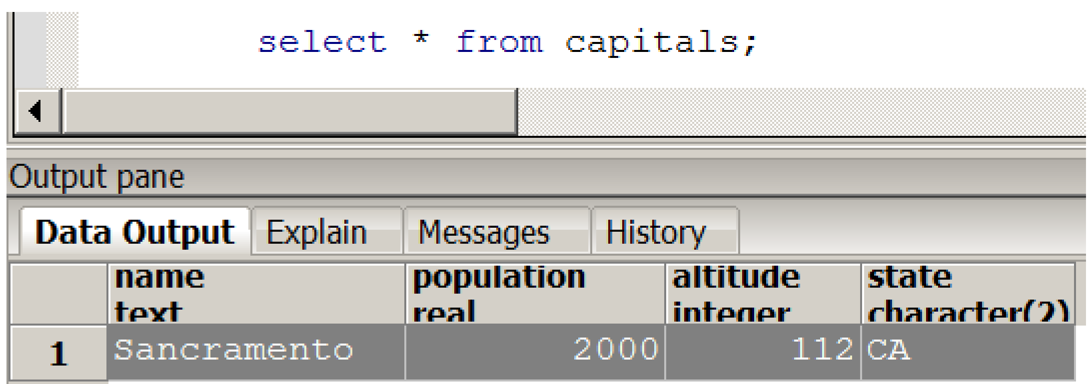
  (state char(2)) INHERITS (cities);

```
-- DROP TABLE public.capitals;

CREATE TABLE public.capitals
(
-- Inherited from table cities:  name text,
-- Inherited from table cities:  population real,
-- Inherited from table cities:  altitude integer,
  state character(2)
)
INHERITS (public.cities)
WITH (
  OIDS=FALSE
);
ALTER TABLE public.capitals
  OWNER TO postgres;
```

Example

- insert into capitals(name, population, altitude, state) values('Sancramento', 2000, 112, 'CA');

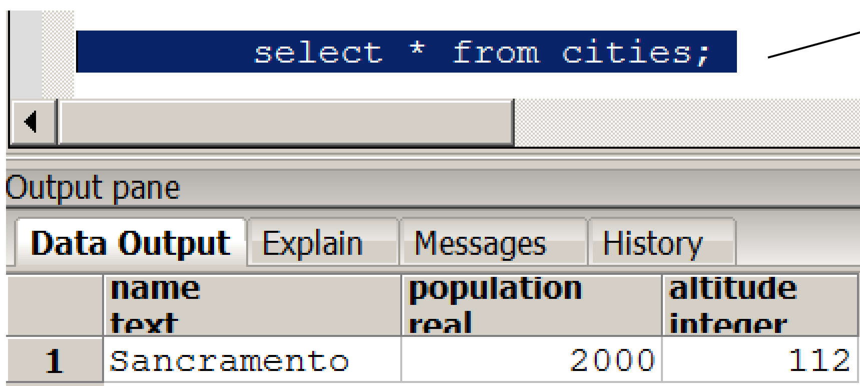


This is more like OO-approach

Caveat

- PostgreSQL *logically" adds a tuple into cities
  - Cities may be regarded as view
  - View: (select * from "non-capital cities") union

    (select name, population, altitude from capitals)



This is more of ER approach

- delete * from capitals
  - Will remove "logical" tuple from cities as well

Translation Review

- Basic cases
  - entity to table, relationship to table
  - selecting attributes based on keys
- Special cases
  - many-one relation can be merged
  - merging many-many is dangerous
  - translating weak entity sets
  - translating isa hierarchy
    - 3 choices, with trade-offs