Introduction to Data Management
CSE 344

Lecture 15: E/R Diagrams

Announcements

- WQ5 due tomorrow (Tuesday)
  - IDREF, IMPLIED etc are explained in book (also in discussion board)
- Homework 4 due Thursday
  - see clarification on Lec 12 slides in the “discussion on lecture notes” area of the discussion board.

- Today: E/R diagrams (4.1-4.6)

Today: E/R Diagrams

Motivating scenario: your boss asks you to setup a DBMS about:

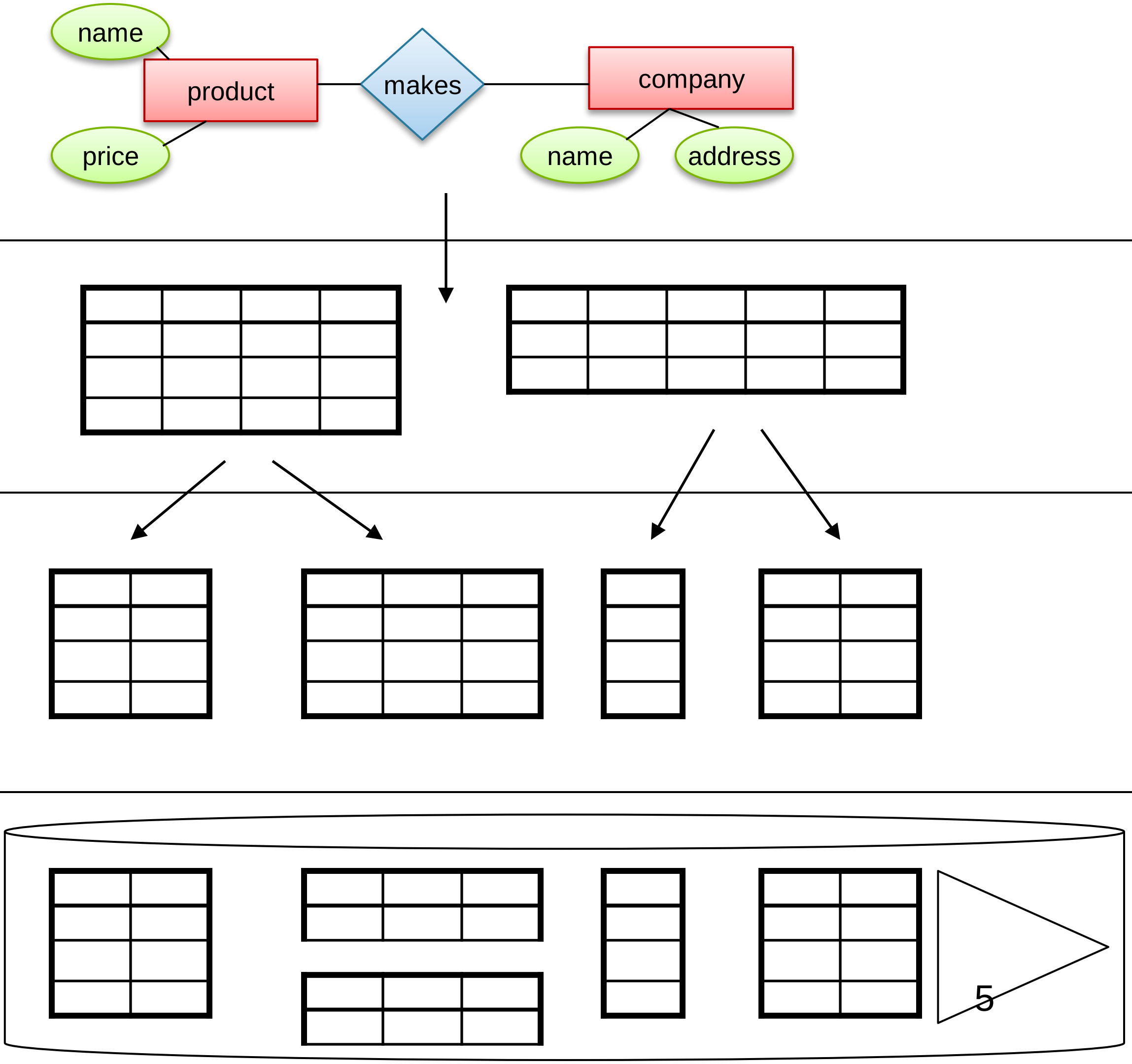
- Companies. Each company has:
  - A name, an address, and a CEO
  - A list of employees, with ssn, name, and address
- Products manufactured by these companies
  - Each product has a name and a price
  - The same product may be manufactured by several companies
- Buyers of these products
  - Each buyer has an ssn, name, and address
  - Some employees may be buyers too

Database Design

- Why do we need it?
  - Need a way to model real world entities in terms of relations
  - Not easy to go from real-world entities to a database schema
- Consider issues such as:
  - What entities to model
  - How entities are related
  - What constraints exist in the domain
  - How to achieve ***good*** designs
- Several formalisms exists
  - We discuss E/R diagrams

Database Design Process

Conceptual Model:



Relational Model:
Tables + constraints
And also functional dep.

Normalization:
Eliminates anomalies

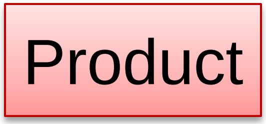
Conceptual Schema

Physical storage details

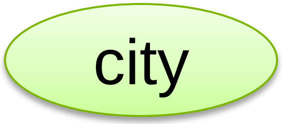
Physical Schema

Entity / Relationship Diagrams

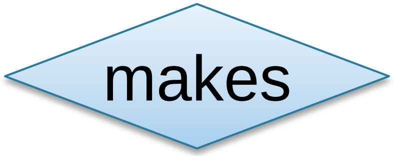
- Entity set = a class
  - An entity = an object


Product

- Attribute


city

- Relationship


makes

E/R Diagram for our Example

Motivating scenario: your boss asks you to setup a DBMS about:

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- Products manufactured by these companies
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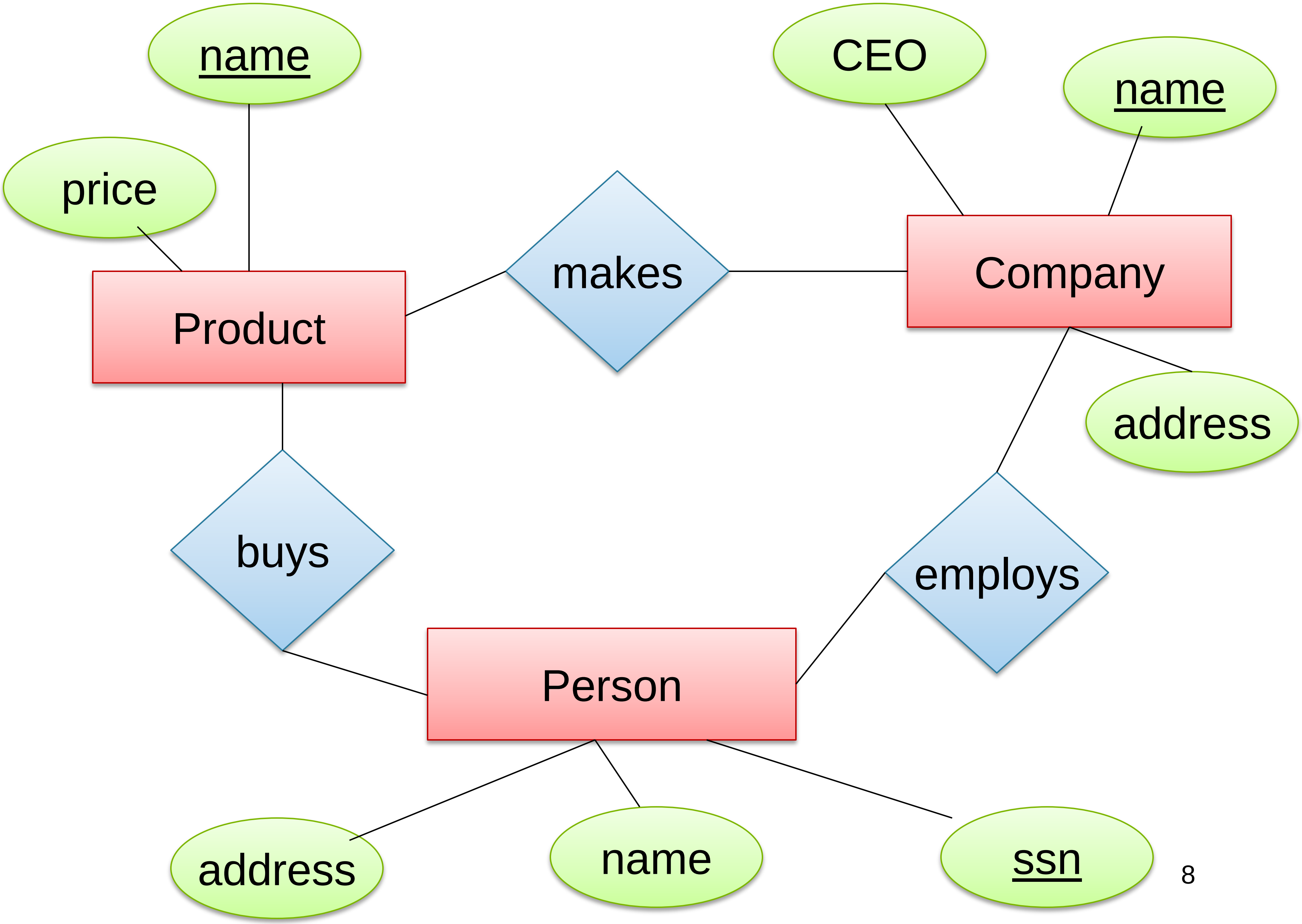
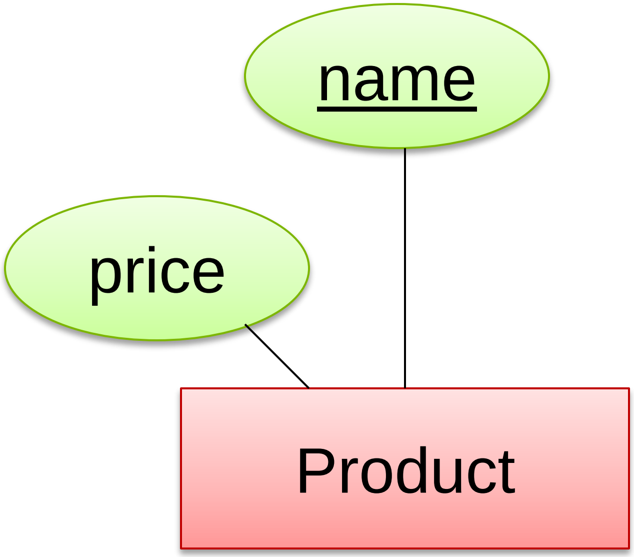

name
CEO
name
price
makes
Company
Product
address
buys
employs
Person
address
name
ssn

Keys in E/R Diagrams

- Every entity set must have a key

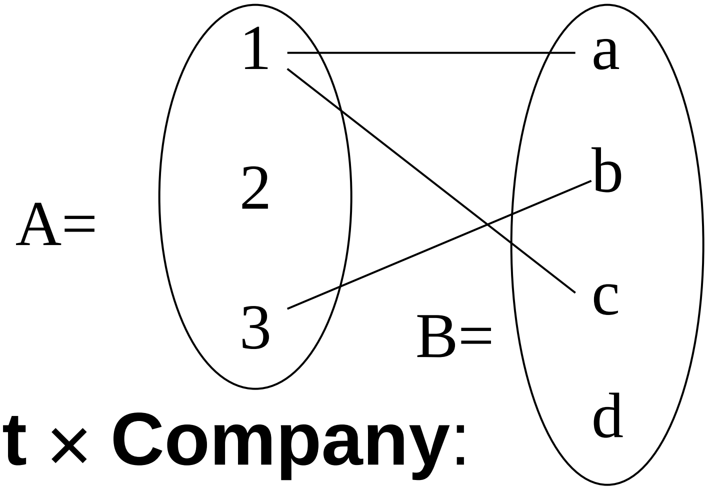


What is a Relation ?

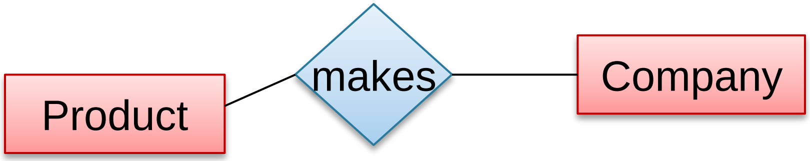
- A mathematical definition:
  - if A, B are sets, then a relation R is a subset of A × B
- A={1,2,3}, B={a,b,c,d},

  A × B = {(1,a),(1,b), . . ., (3,d)}

  R = {(1,a), (1,c), (3,b)}

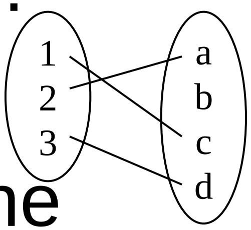


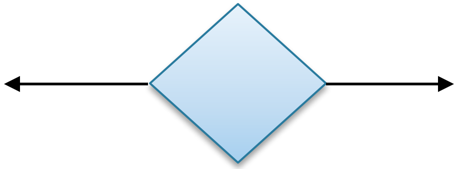
- **makes** is a subset of **Product × Company**:



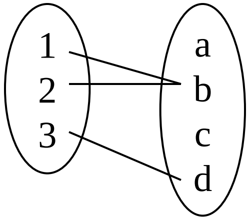
Multiplicity of E/R Relations

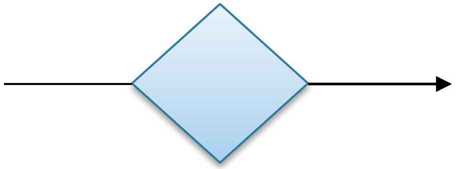
- one-one:



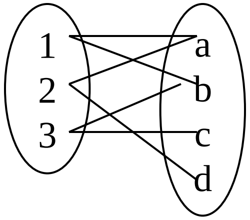


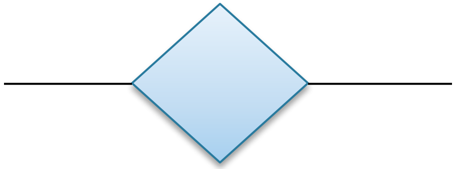
- many-one

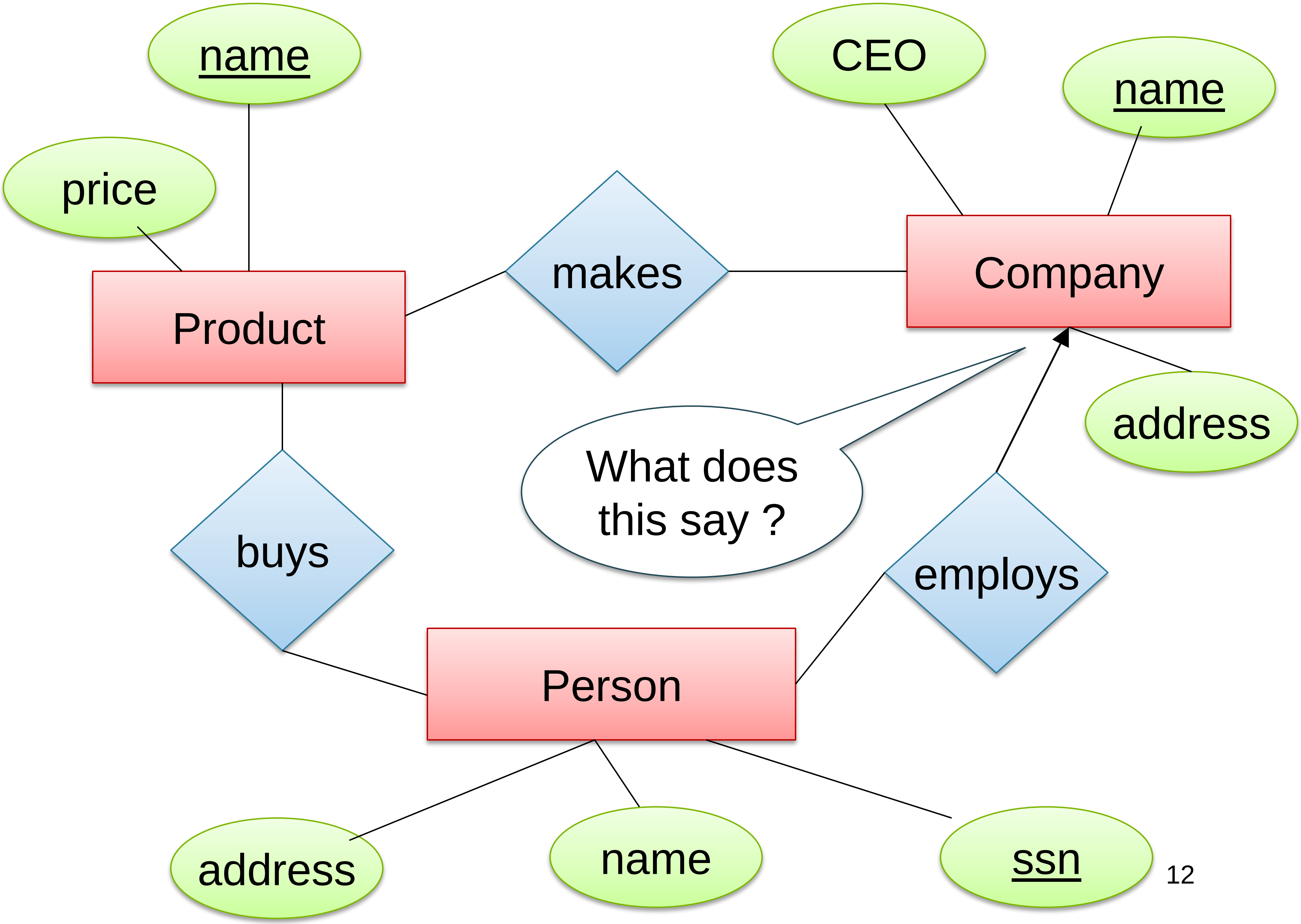




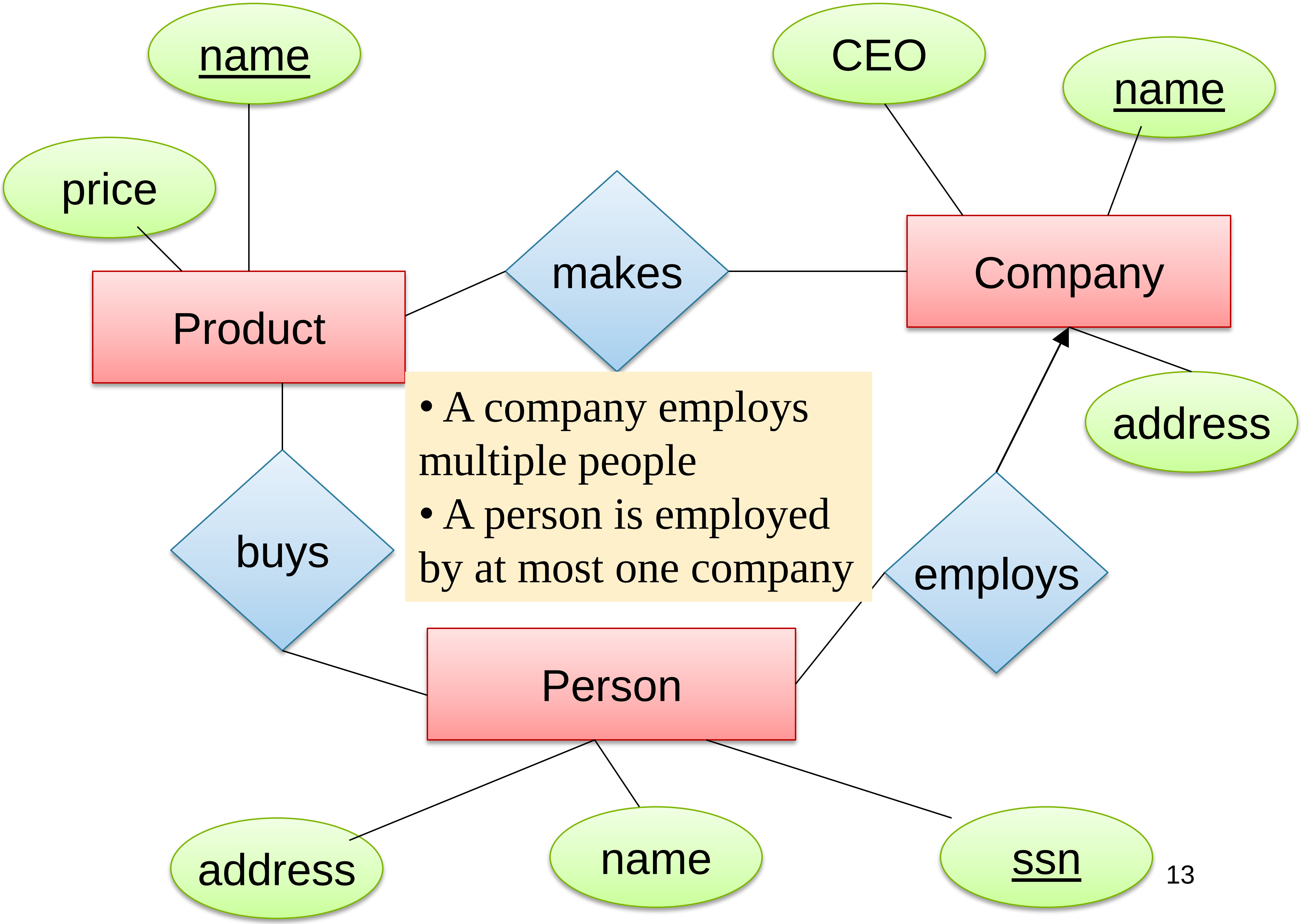
- many-many







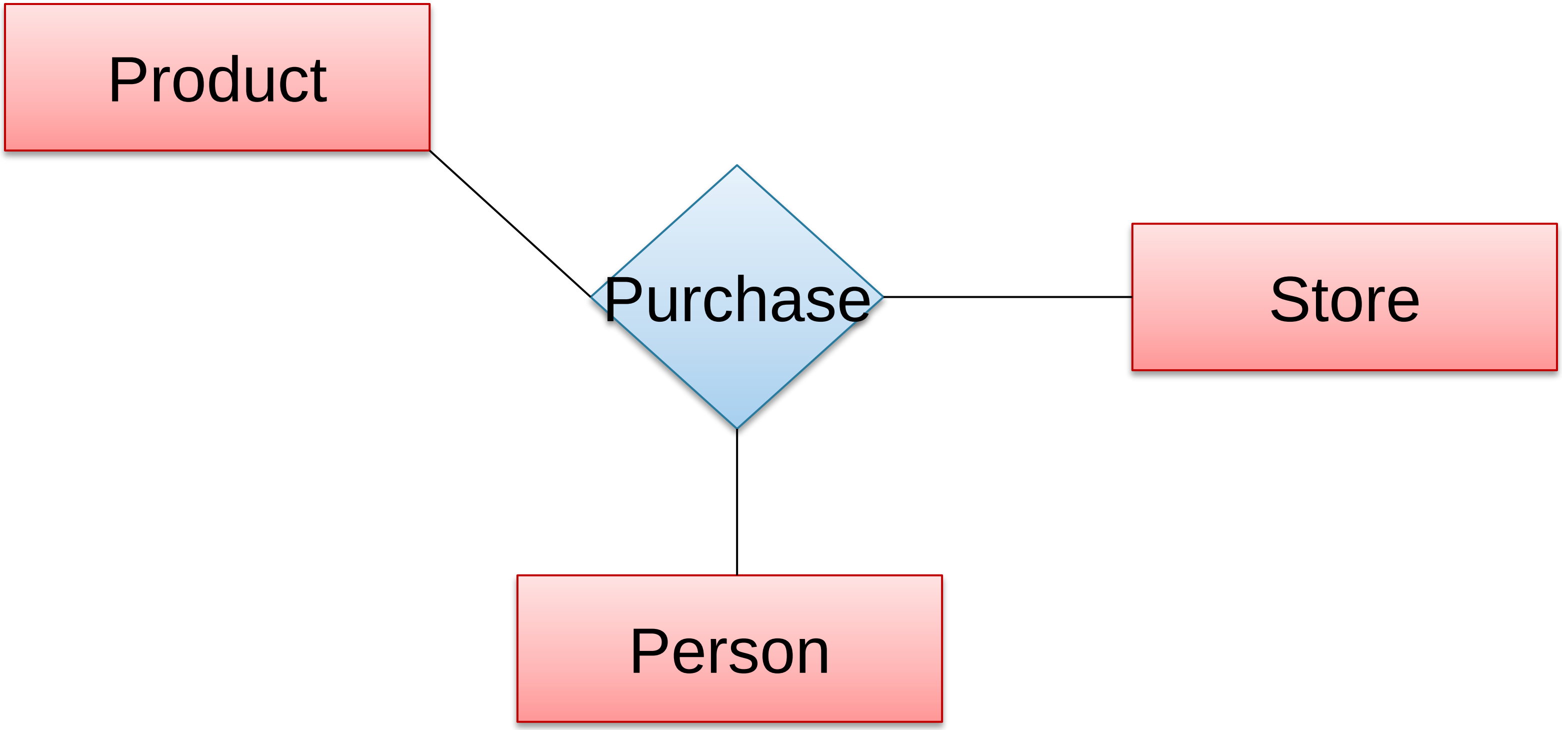
What does this say ?



- A company employs multiple people
- A person is employed by at most one company

Multi-way Relationships

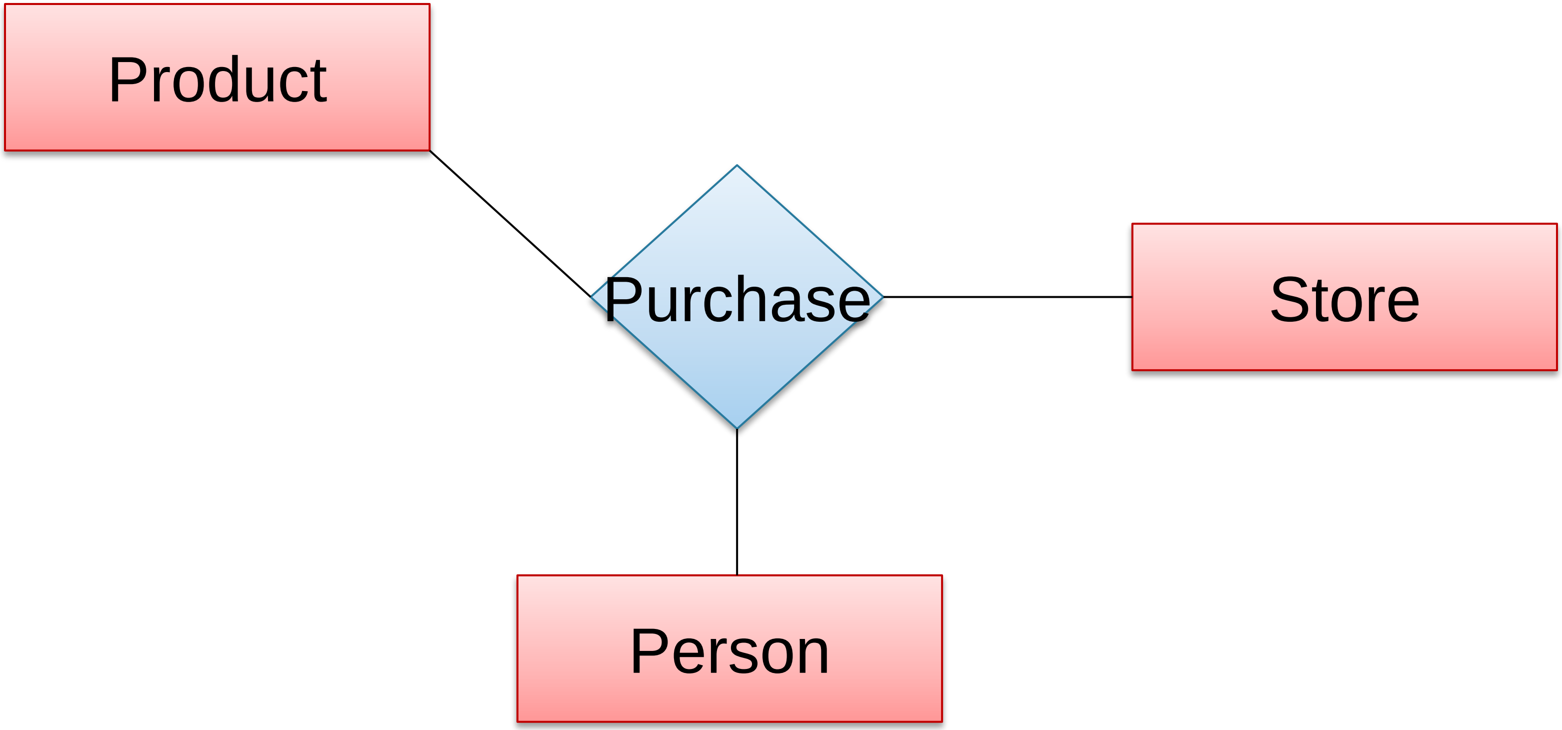
How do we model a purchase relationship between buyers, products and stores?



Can still model as a mathematical set (Q. how ?)

Multi-way Relationships

How do we model a purchase relationship between buyers, products and stores?

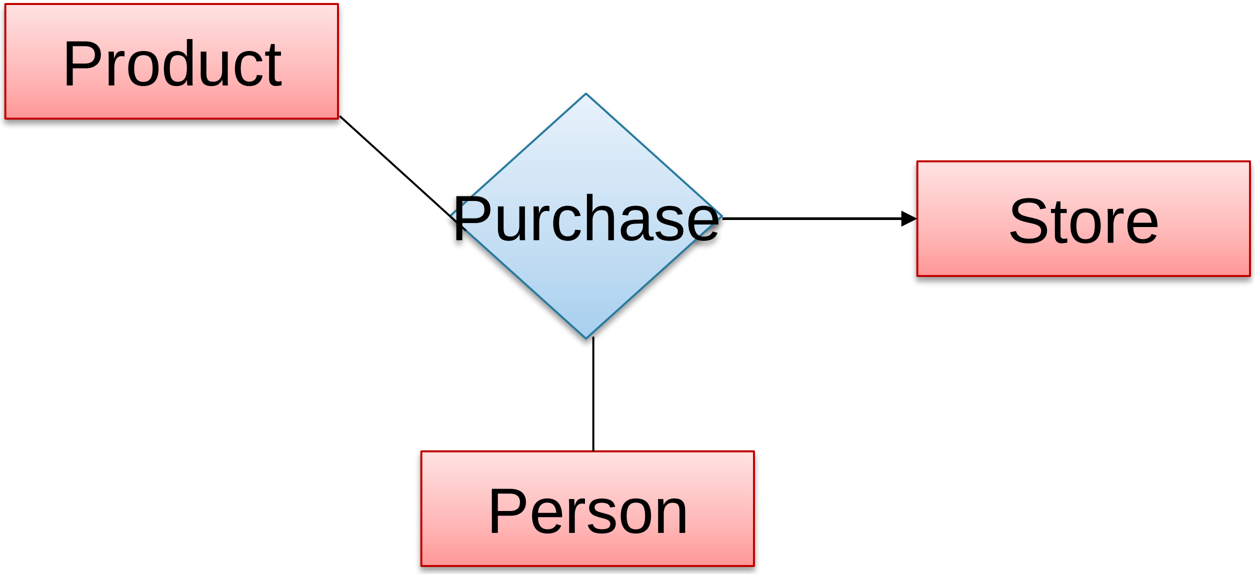


Can still model as a mathematical set (Q. how ?)

A. As a set of triples $\subseteq$ Person × Product × Store

Arrows in Multiway Relationships

Q: What does the arrow mean ?

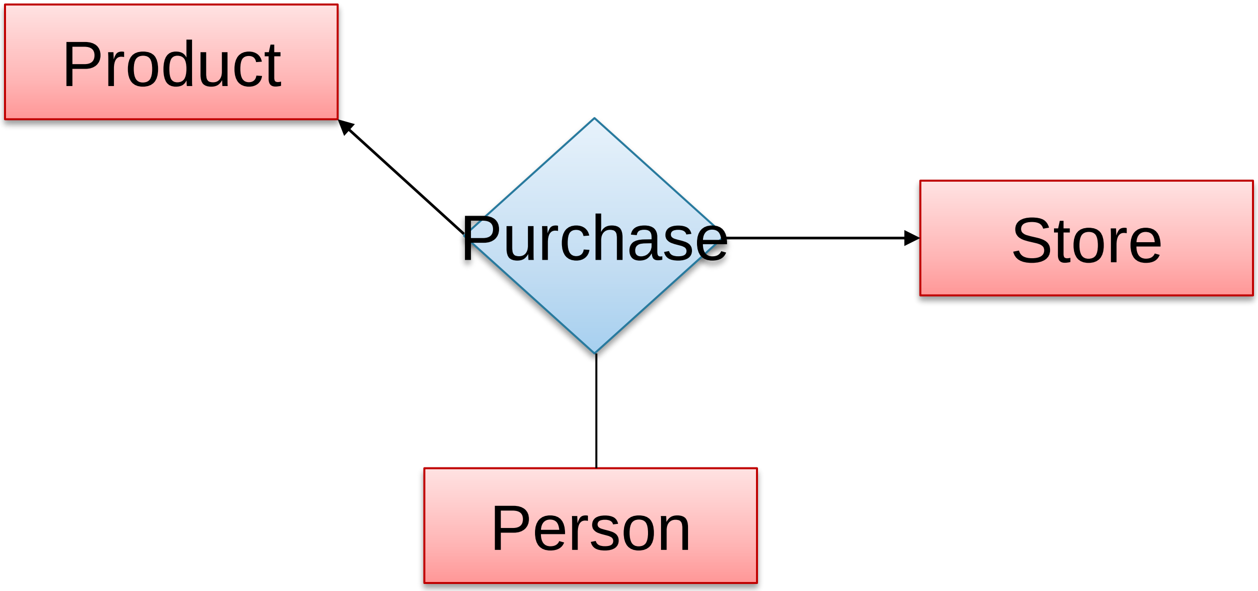


A: A given person buys a given product from at most one store

[Arrow pointing to E means that if we select one entity from each of the other entity sets in the relationship, those entities are related to at most one entity in E]

Arrows in Multiway Relationships

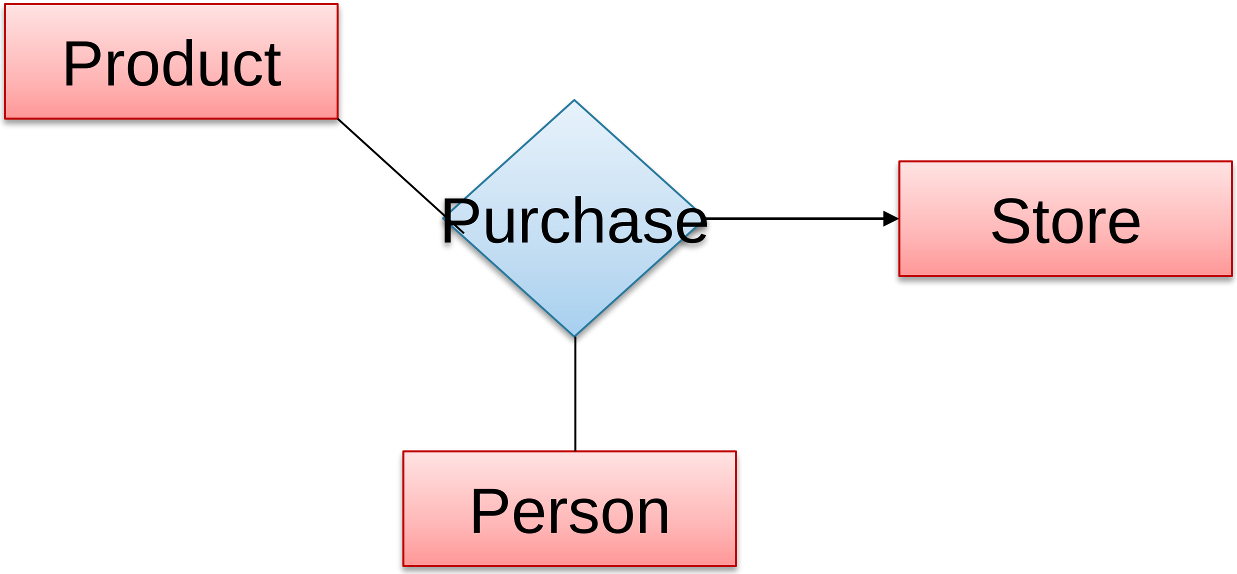
Q: What does the arrow mean ?



A: A given person buys a given product from at most one store AND every store sells to every person at most one product

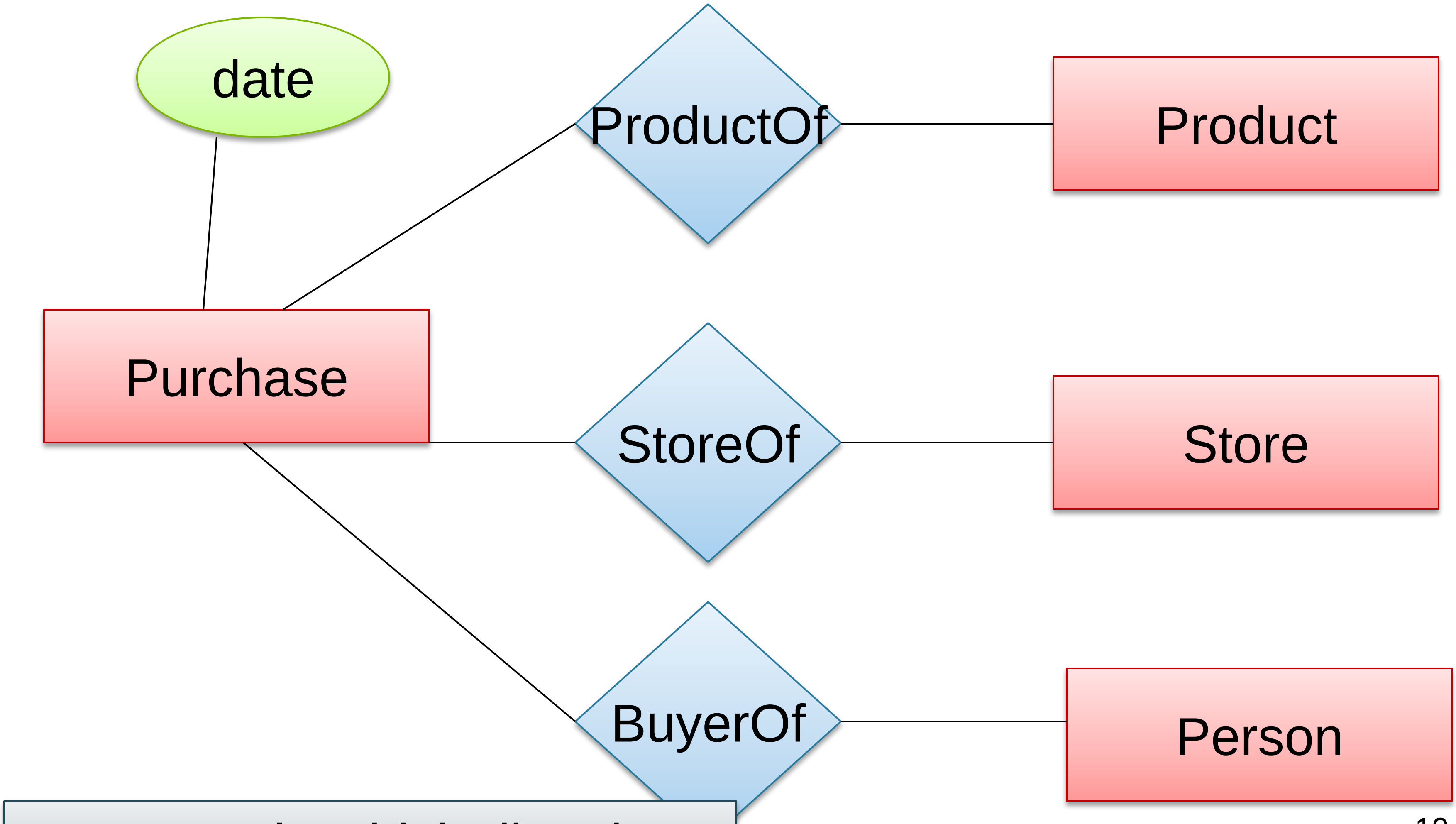
Arrows in Multiway Relationships

Q: How do we say that every person shops at at most one store ?



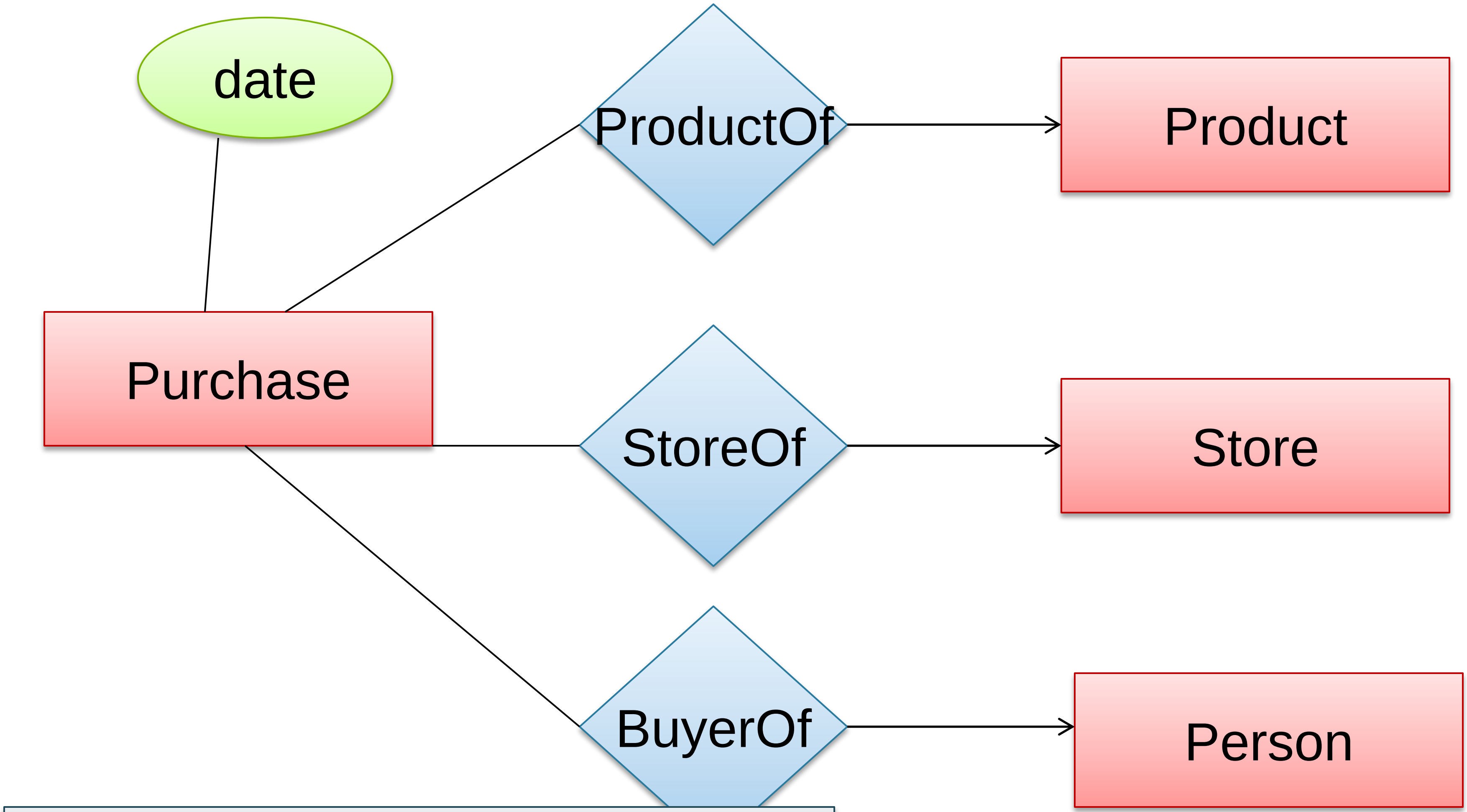
A: Cannot. This is the best approximation.
(Why only approximation ?)

Converting Multi-way Relationships to Binary



Arrows go in which direction?

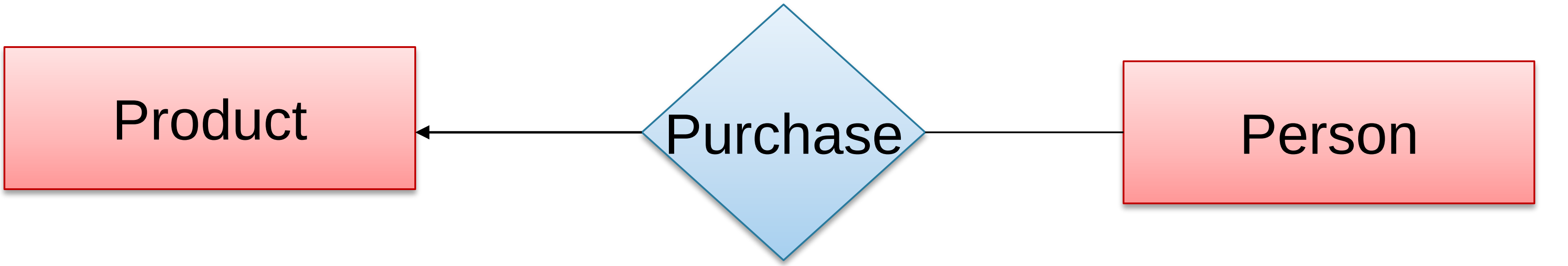
Converting Multi-way Relationships to Binary

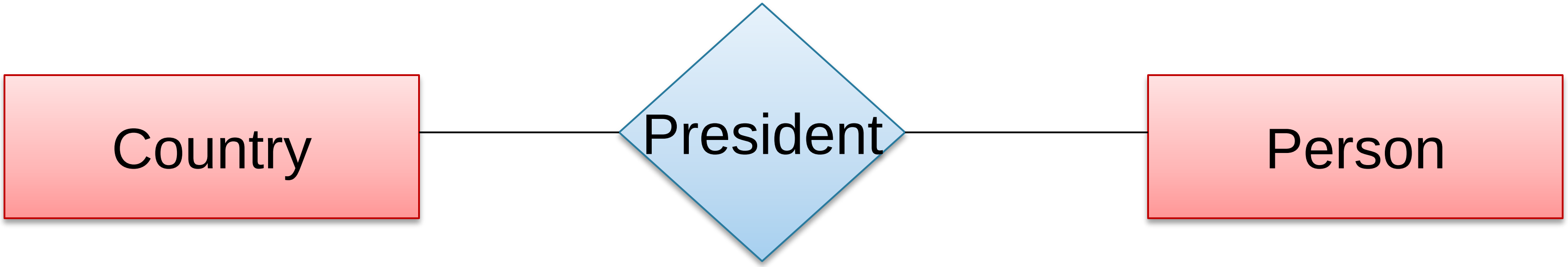


Make sure you understand why!

3. Design Principles

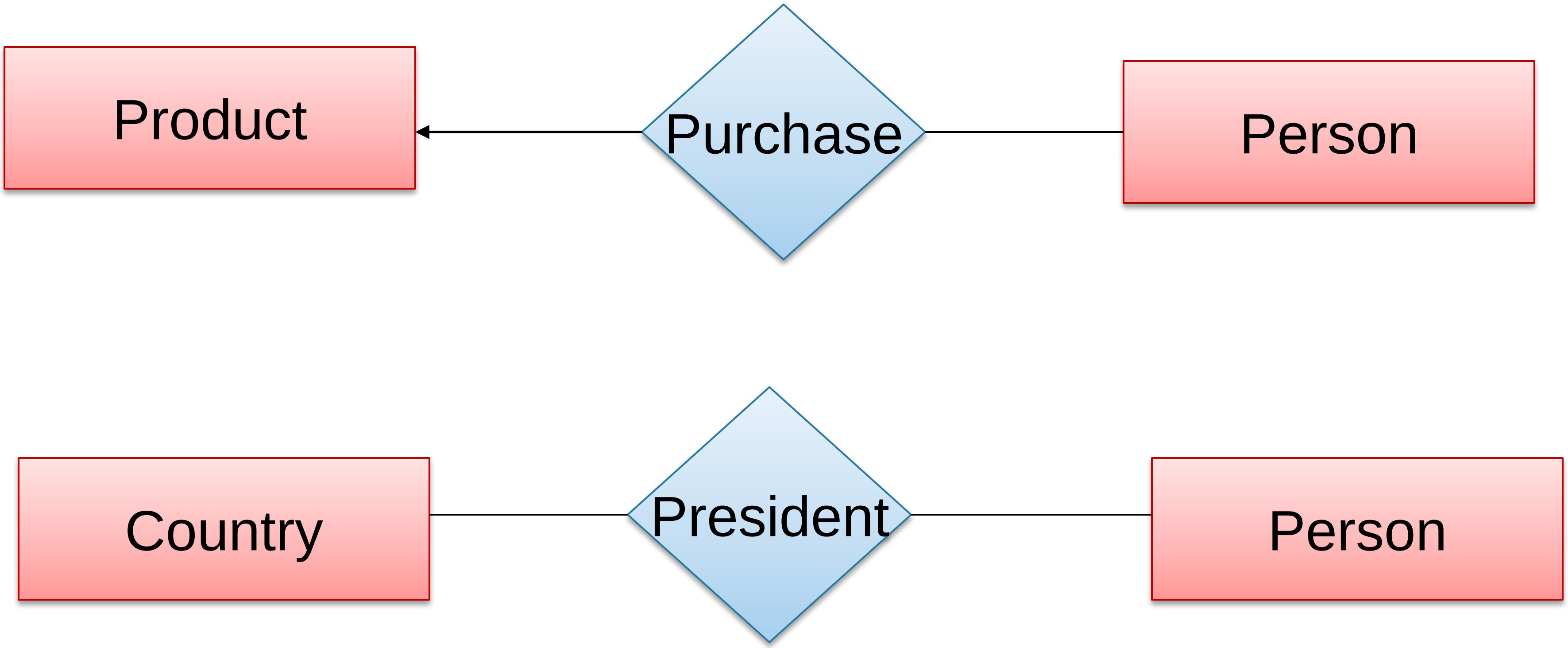
What's wrong?





3. Design Principles

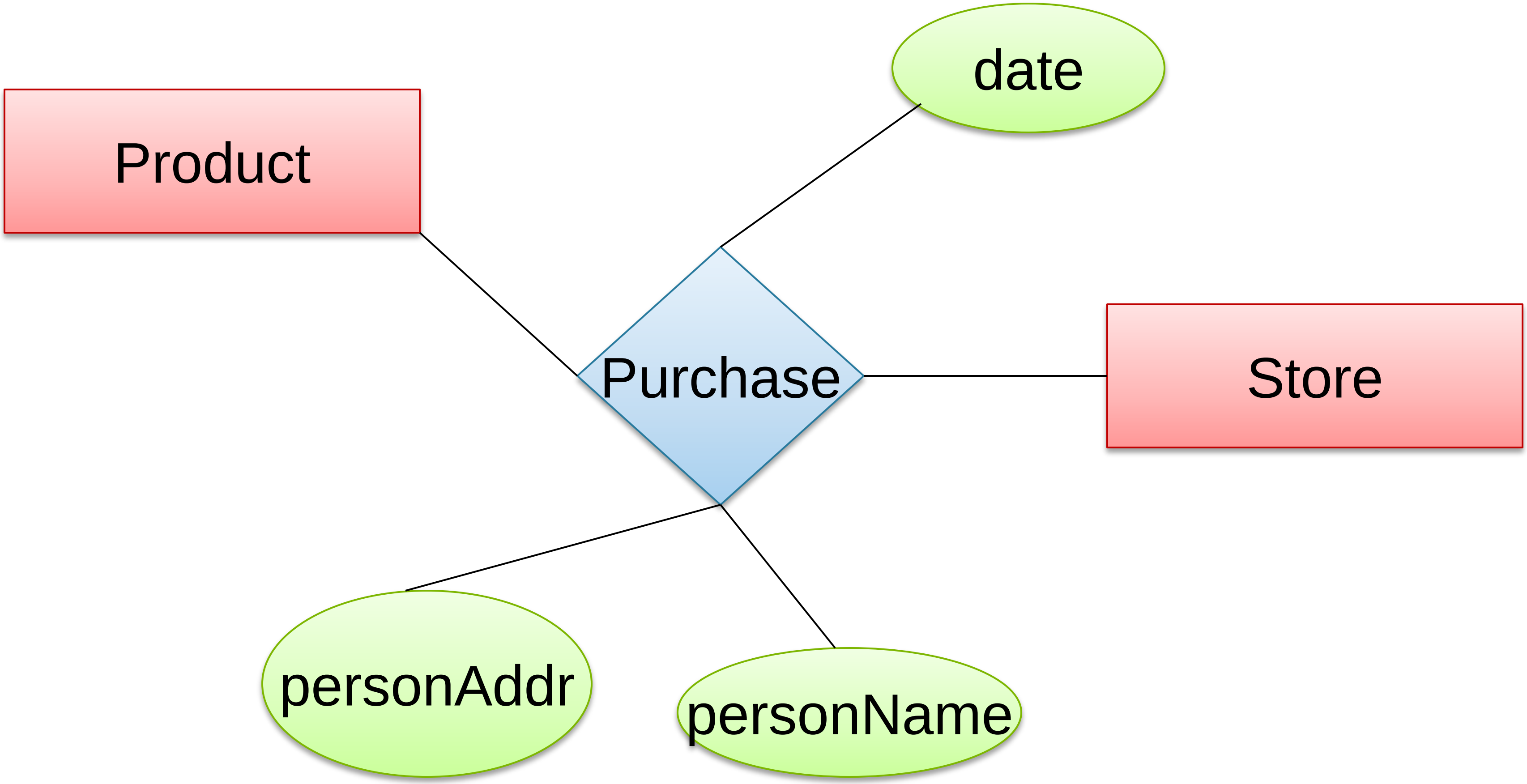
What's wrong?



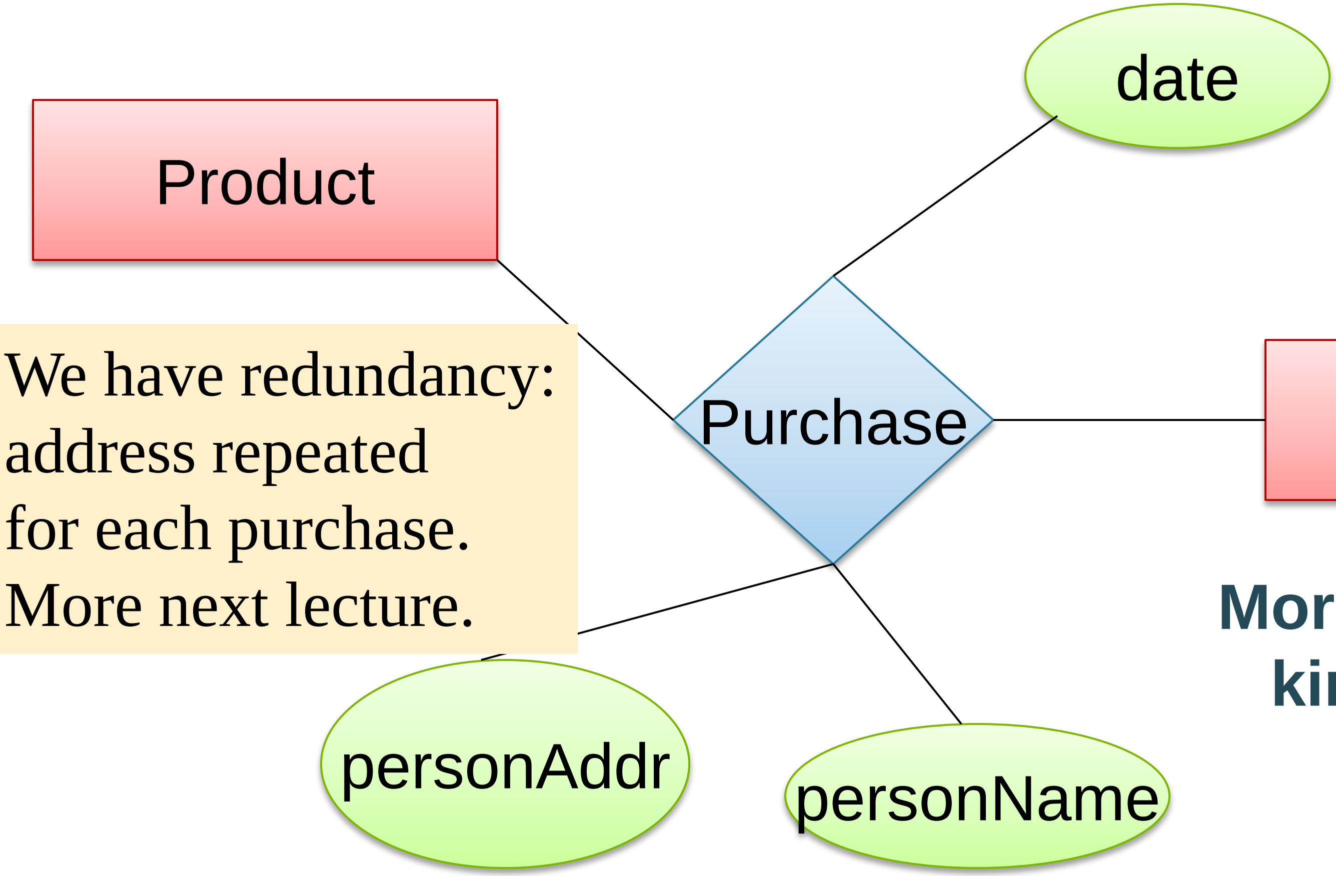
Design does not reflect reality

Moral: be faithful to the specifications of the app!

Design Principles: What's Wrong?



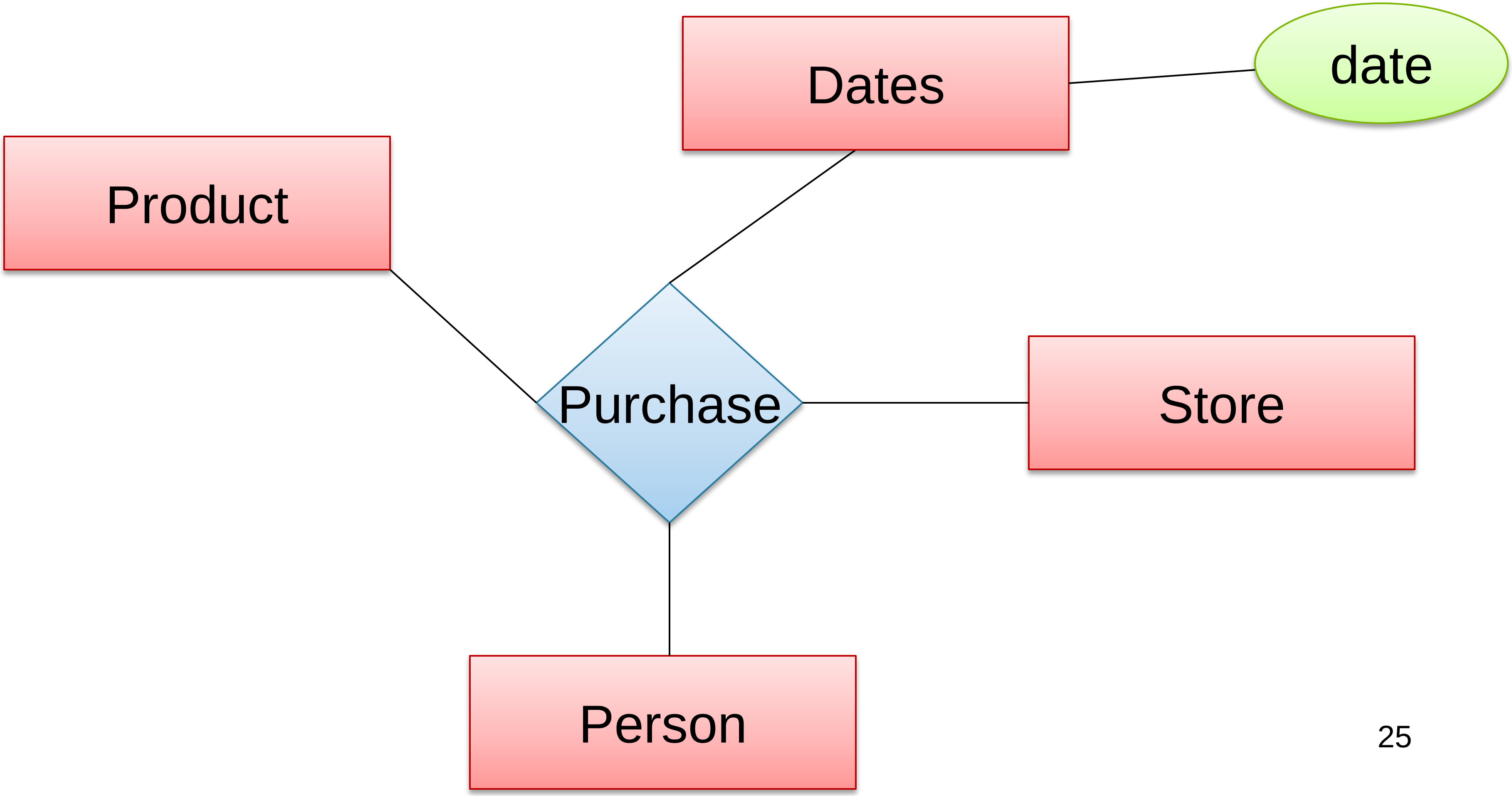
Design Principles: What's Wrong?



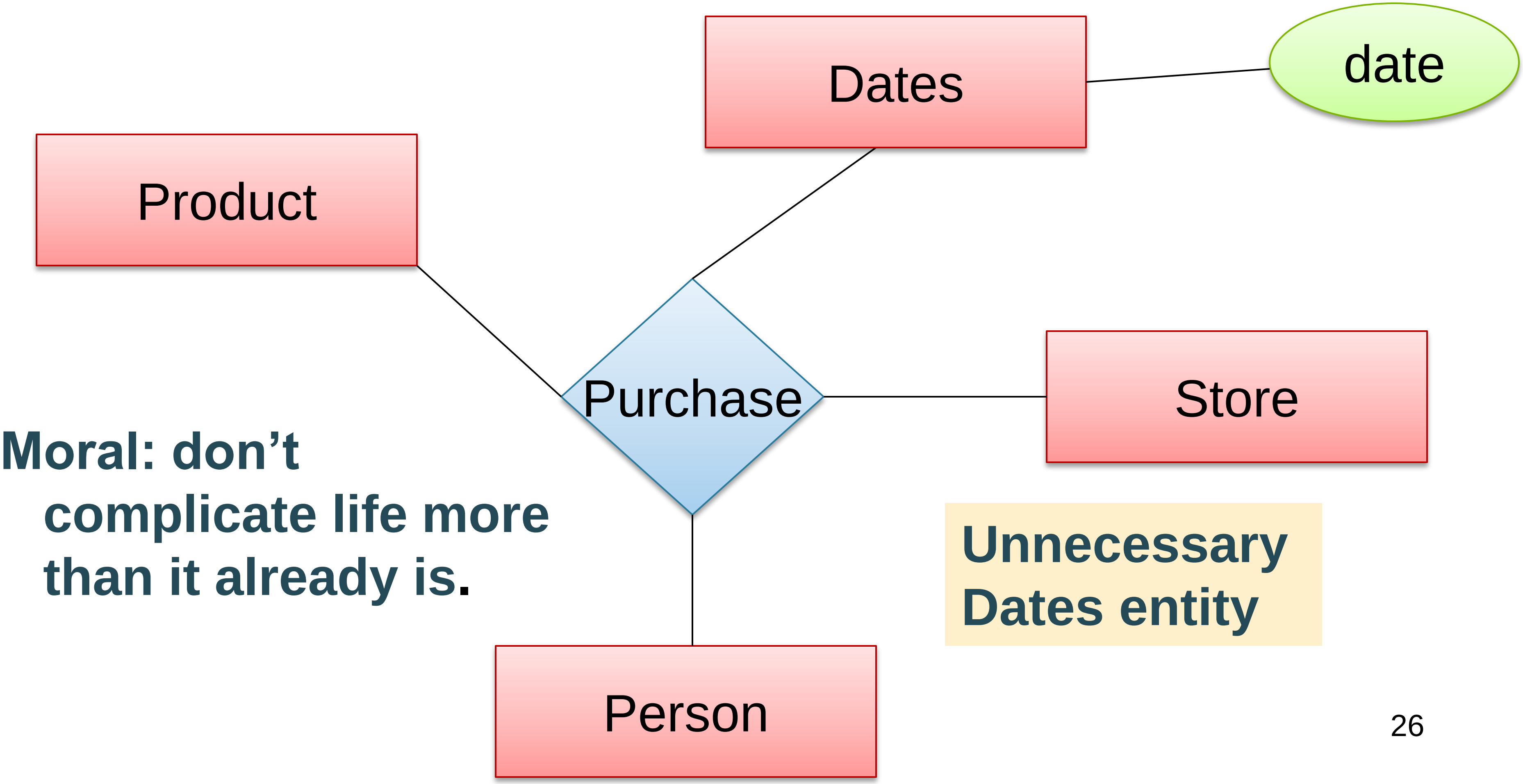
We have redundancy: address repeated for each purchase. More next lecture.

Moral: pick the right kind of entities.

Design Principles: What's Wrong?



Design Principles: What's Wrong?



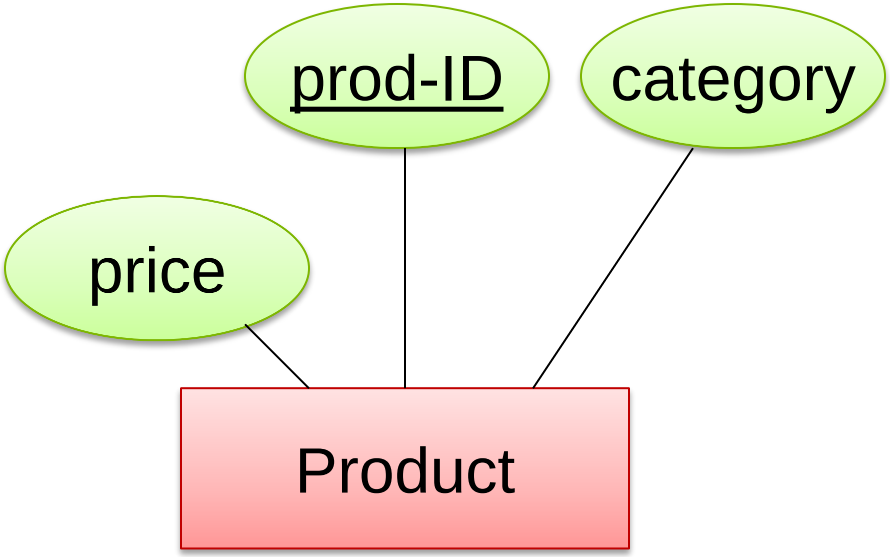
Moral: don't complicate life more than it already is.

Unnecessary Dates entity

From E/R Diagrams to Relational Schema

- Entity set → relation
- Relationship → relation

Entity Set to Relation



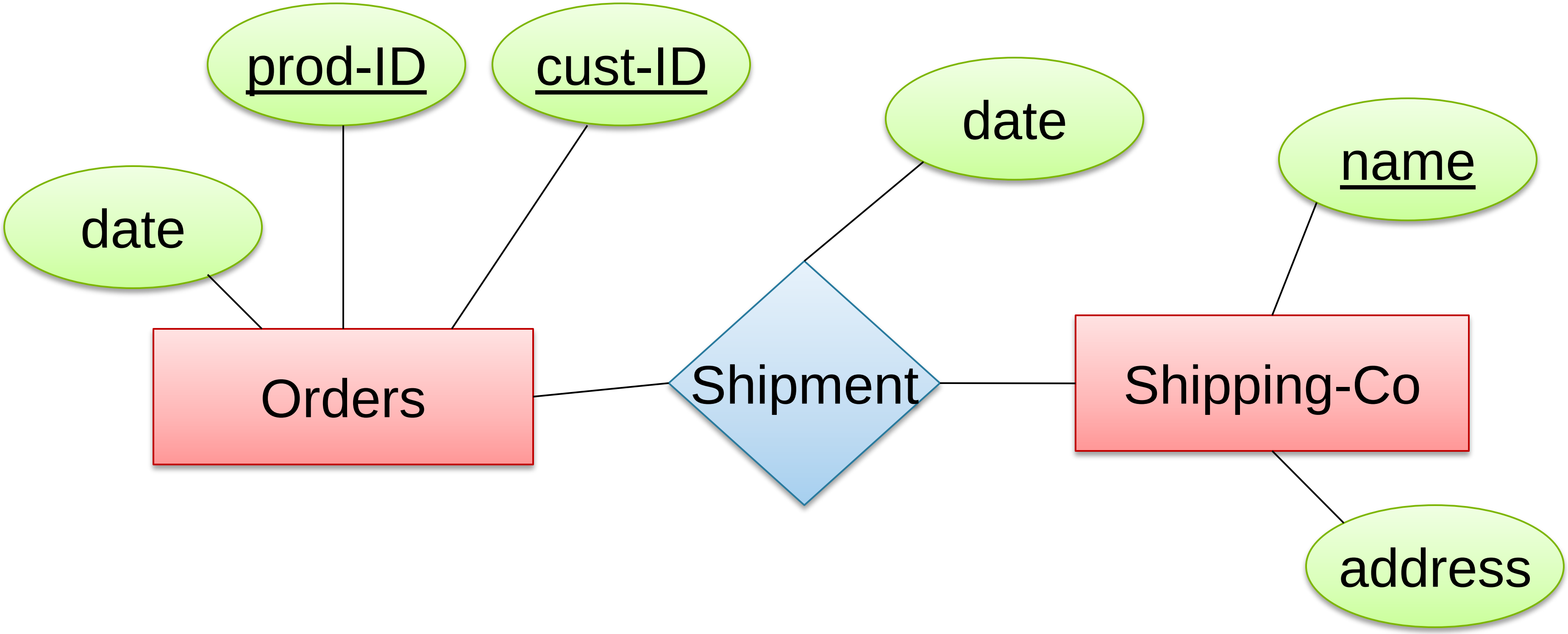
Product(<u>prod-ID</u>, category, price)

<u>prod-ID</u>	category	price
Gizmo55	Camera	99.99
Pokemn19	Toy	29.99

Create Table (SQL)

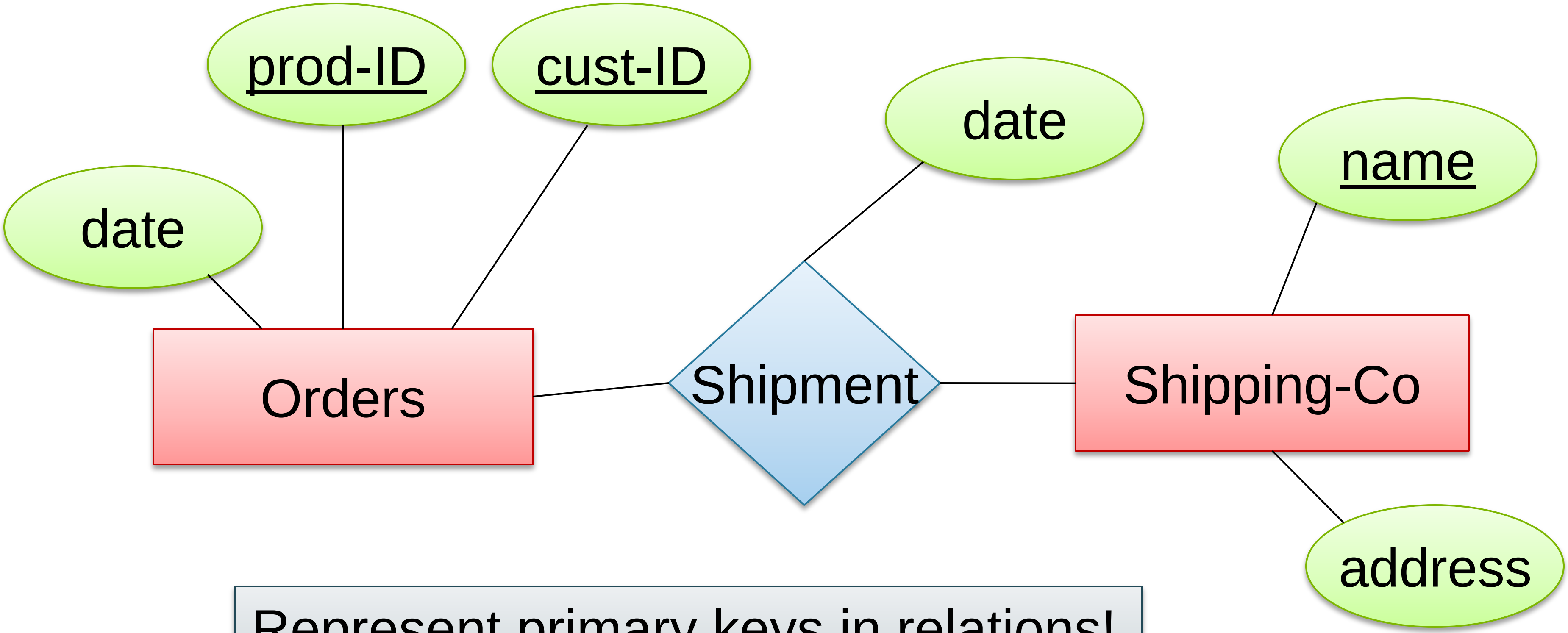
```
CREATE TABLE Product (
        prod-ID CHAR(30) PRIMARY KEY,
        category VARCHAR(20),
         price double)
```

N-N Relationships to Relations



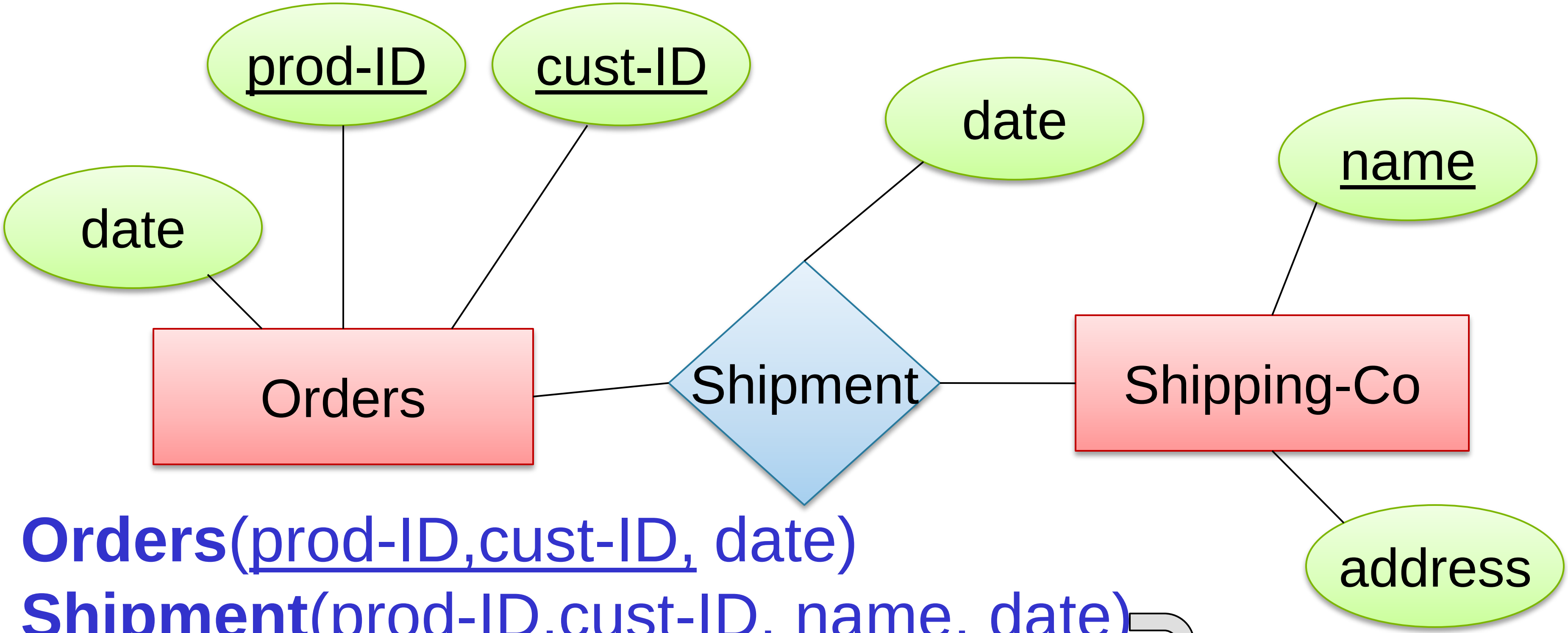
Q. What to include in the relations?

N-N Relationships to Relations



Represent primary keys in relations!
Also any attribute of the relationship

N-N Relationships to Relations



Orders(prod-ID,cust-ID, date)

Shipment(prod-ID,cust-ID, name, date)

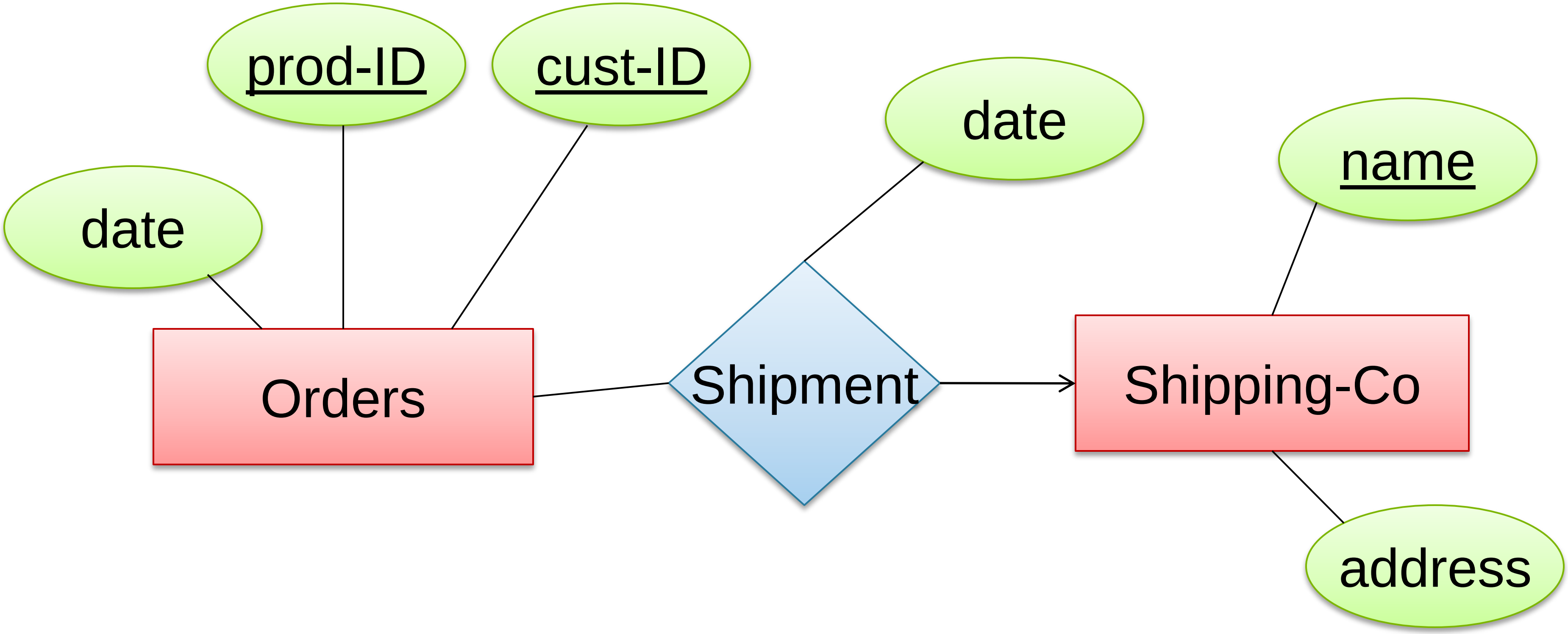
Shipping-Co(name, address)

prod-ID	cust-ID	name	date
Gizmo55	Joe12	UPS	4/10/2011
Gizmo55	Joe12	FEDEX	4/9/2011

Create Table (SQL)

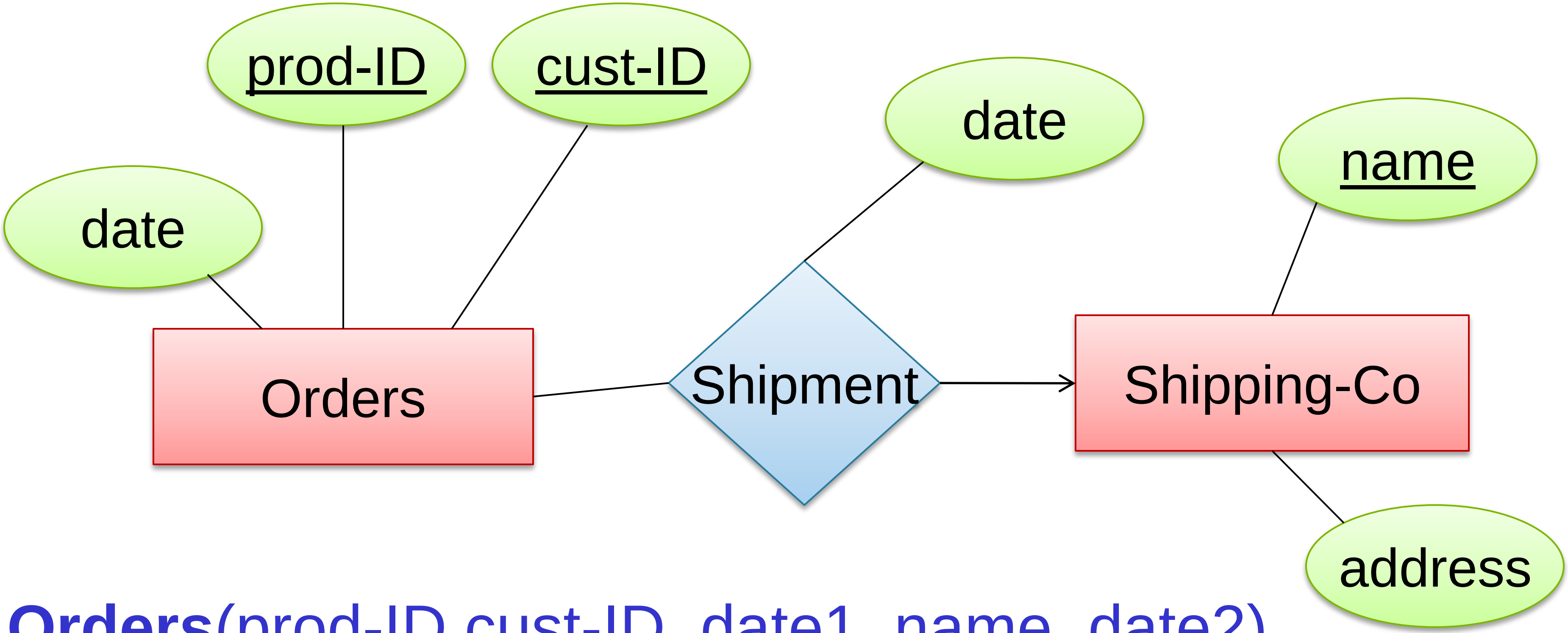
```
CREATE TABLE Shipment(
         name CHAR(30)
                  REFERENCES Shipping-Co,
          prod-ID CHAR(30),
          cust-ID VARCHAR(20),
         date DATETIME,
PRIMARY KEY (name, prod-ID, cust-ID),
FOREIGN KEY (prod-ID, cust-ID)
            REFERENCES  Orders
)
```

N-1 Relationships to Relations



Q. Do you need a separate relation for a N-1 relationship?

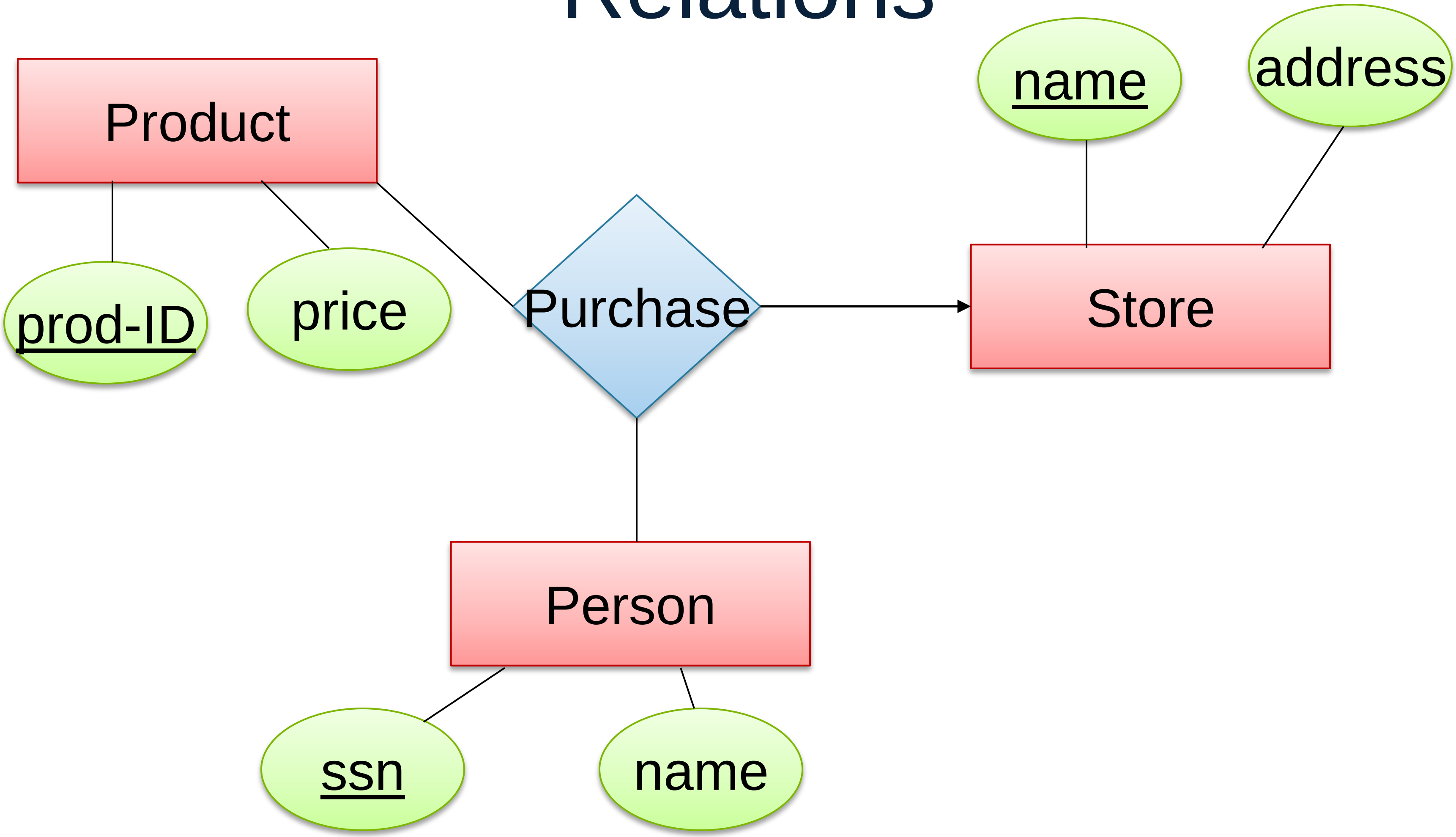
N-1 Relationships to Relations



Orders(prod-ID,cust-ID, date1, name, date2)
Shipping-Co(name, address)

Remember: no separate relations for many-one relationship

Multi-way Relationships to Relations

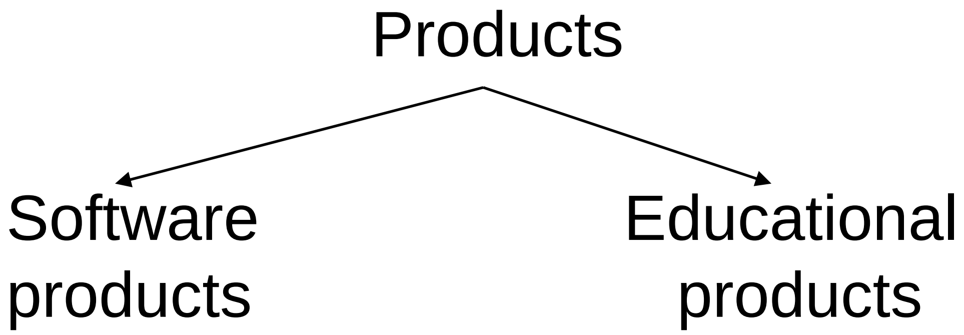


Purchase(prod-ID, cust-ssn, store-name)

Modeling Subclasses

Some objects in a class may be special

- define a new class
- better: define a *subclass*

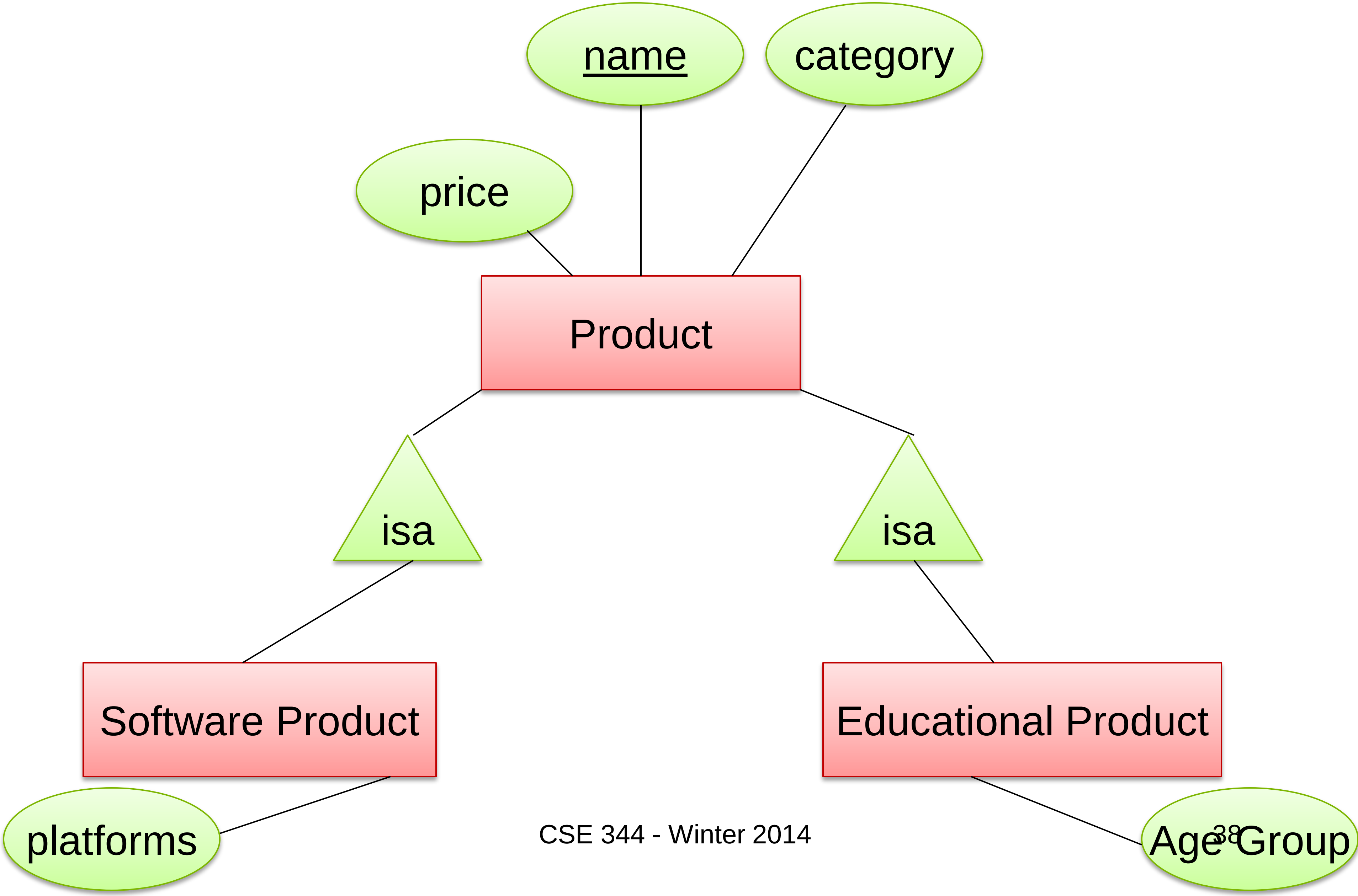

Products

Software products

Educational products

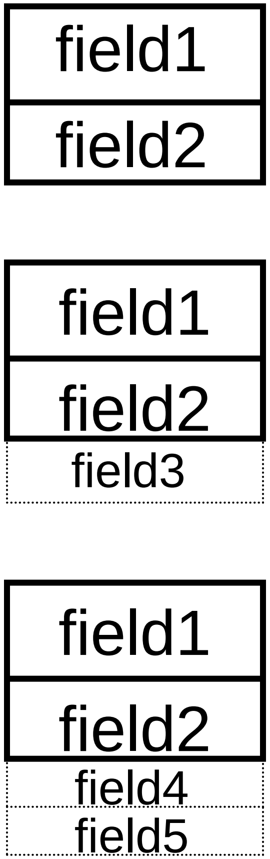
So --- we define subclasses in E/R

Subclasses


name
category
price
Product
isa
isa
Software Product
Educational Product
platforms
Age Group

Understanding Subclasses

- Think in terms of records:
  - Product
  - SoftwareProduct
  - EducationalProduct

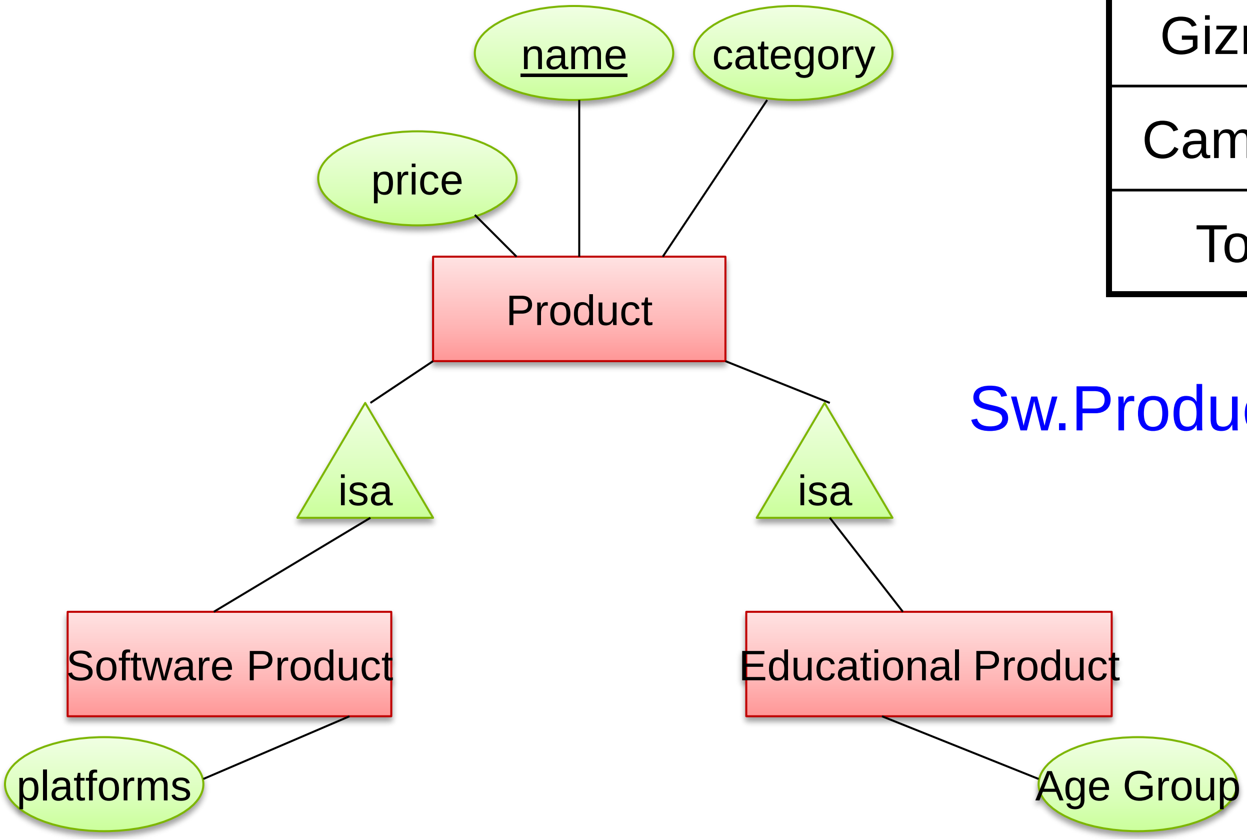


field1
field2

field1
field2
field3

field1
field2
field4
field5

Subclasses to Relations



Product

Name	Price	Category
Gizmo	99	gadget
Camera	49	photo
Toy	39	gadget

Sw.Product

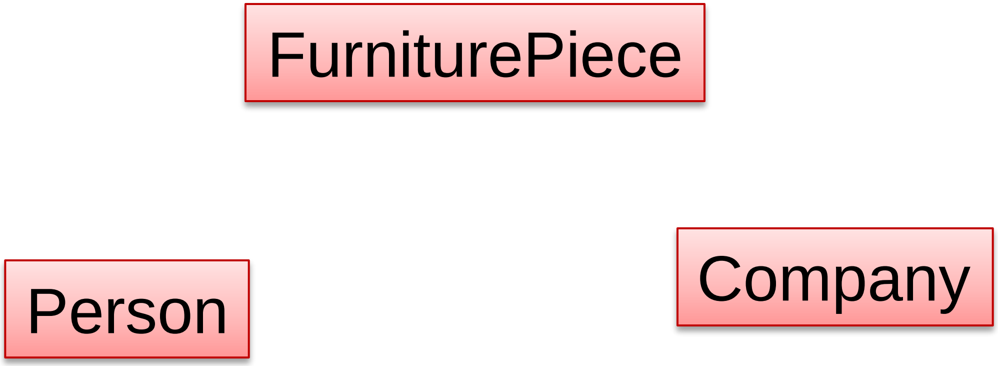
Name	platforms
Gizmo	unix

Ed.Product

Name	Age Group
Gizmo	toddler
Toy	retired

Other ways to convert are possible

Modeling UnionTypes With Subclasses

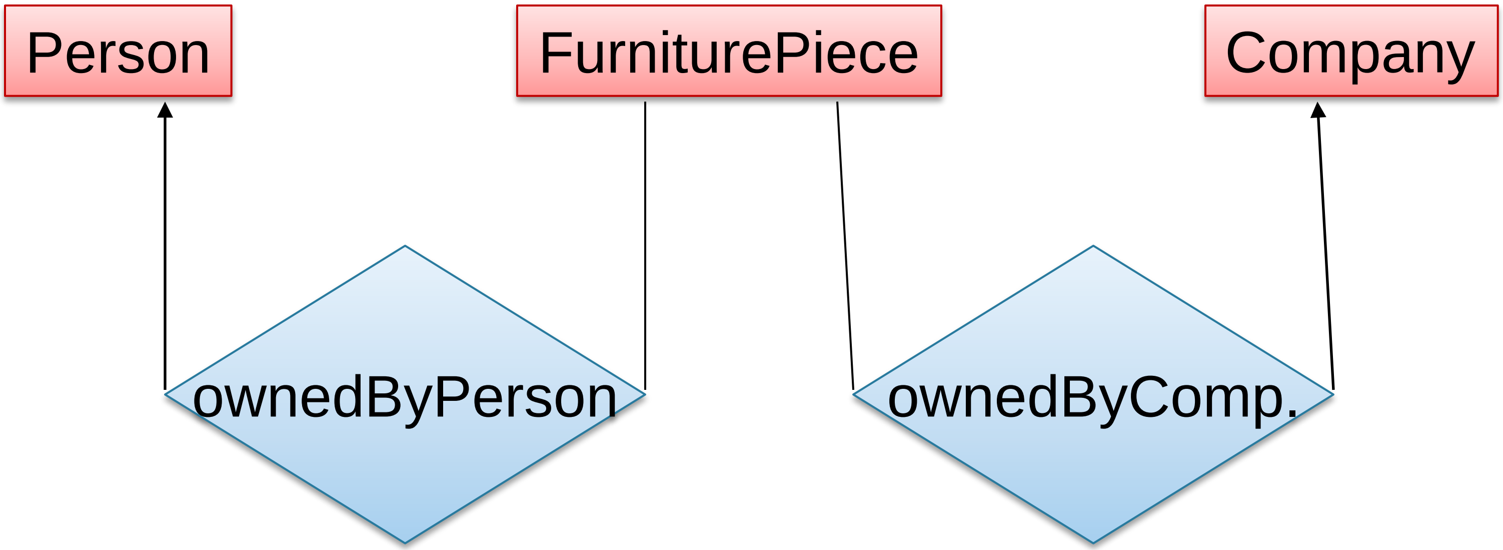


Say: each piece of furniture is owned either by a person or by a company

Modeling Union Types with Subclasses

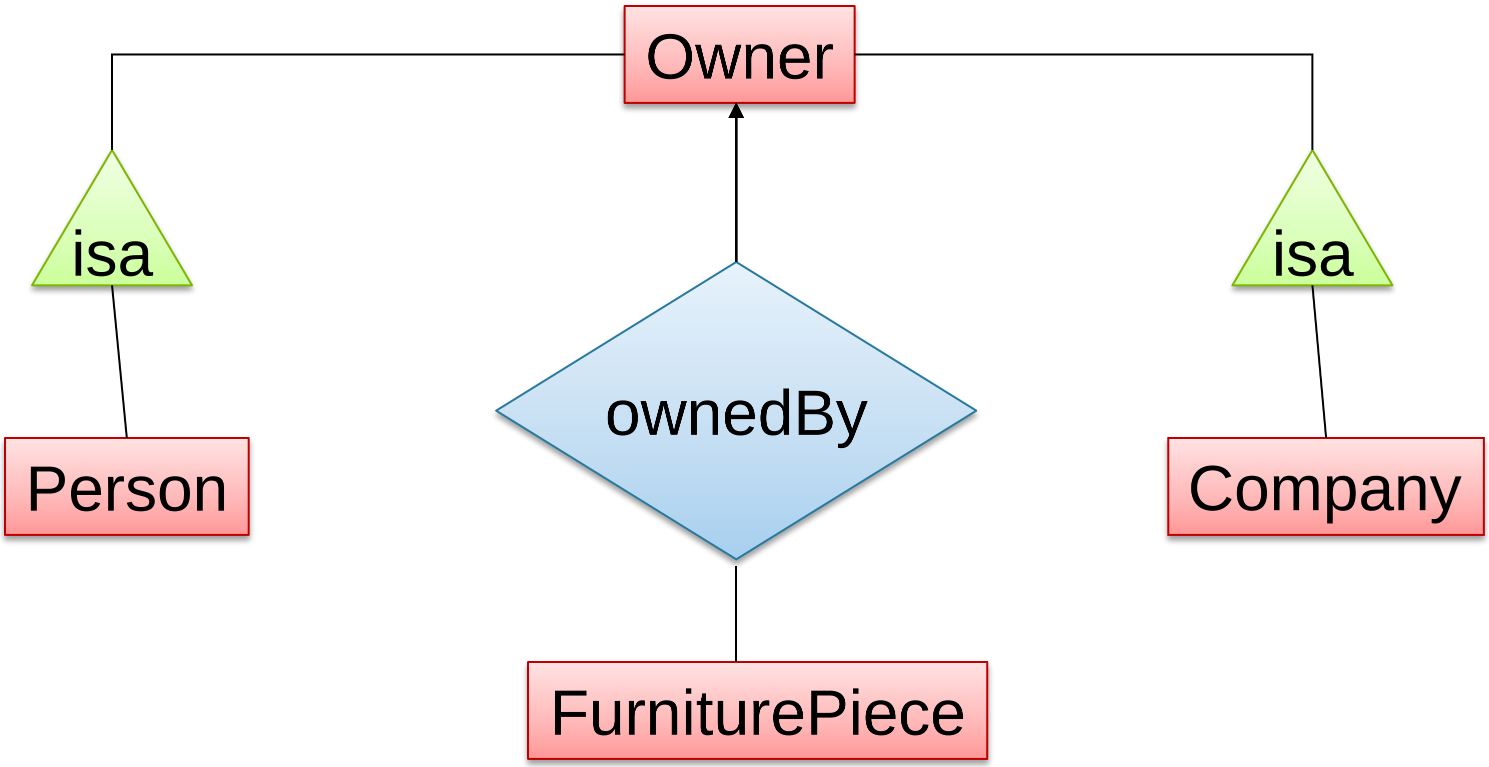
Say: each piece of furniture is owned either by a person or by a company

Solution 1. Acceptable but imperfect (What's wrong ?)



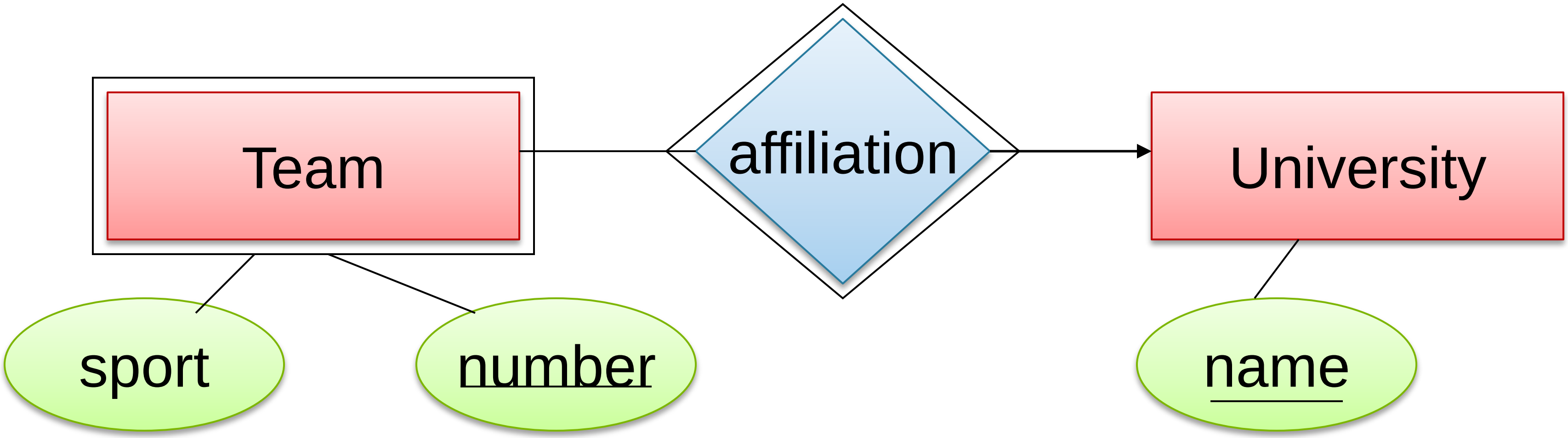
Modeling Union Types with Subclasses

Solution 2: better, more laborious



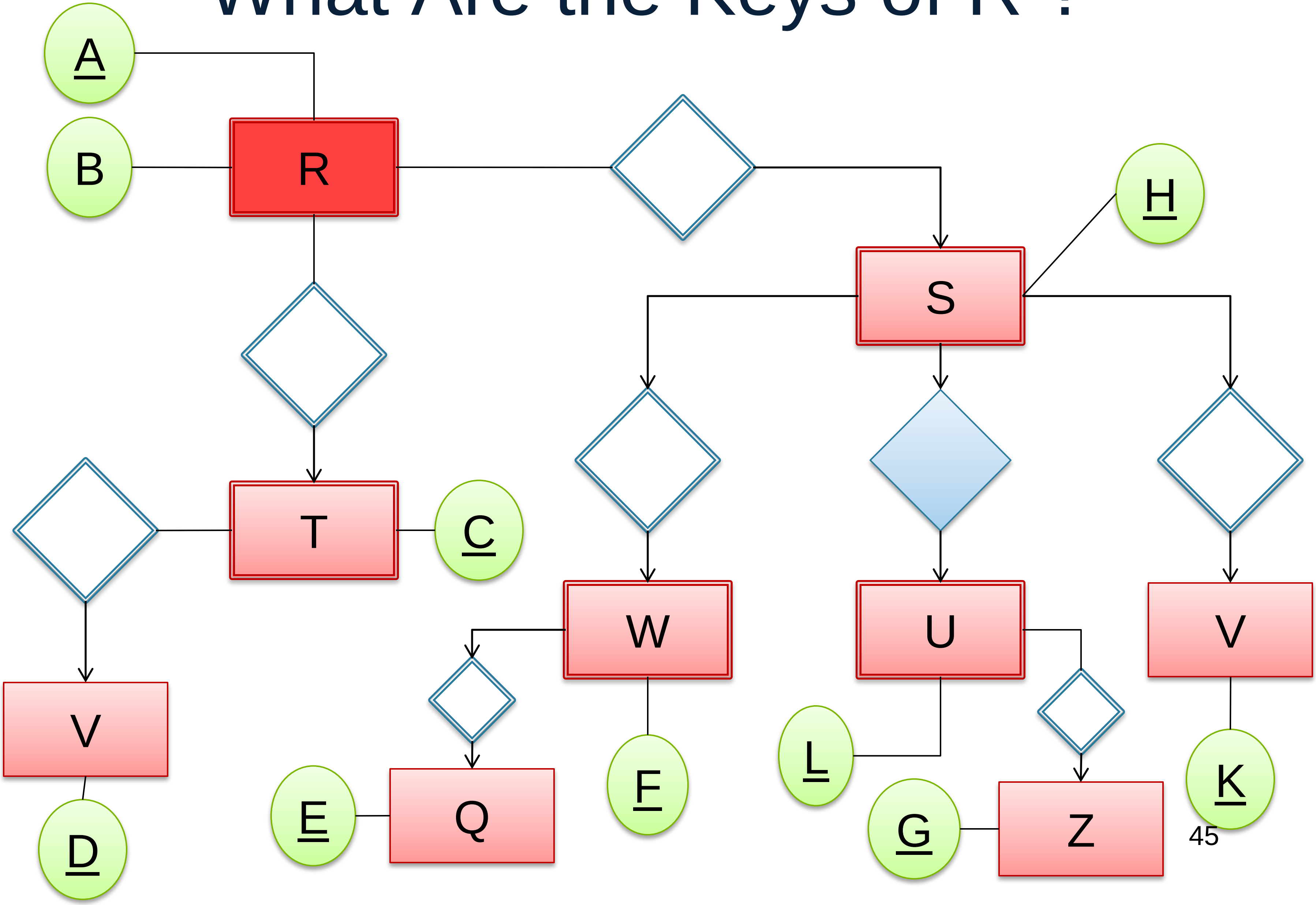
Weak Entity Sets

Entity sets are weak when their key comes from other classes to which they are related.



Team(sport, <u>number, universityName</u>)
University(<u>name</u>)

What Are the Keys of R ?



Constraints in E/R Diagrams

Finding constraints is part of the modeling process.
Commonly used constraints:

Keys: social security number uniquely identifies a person.

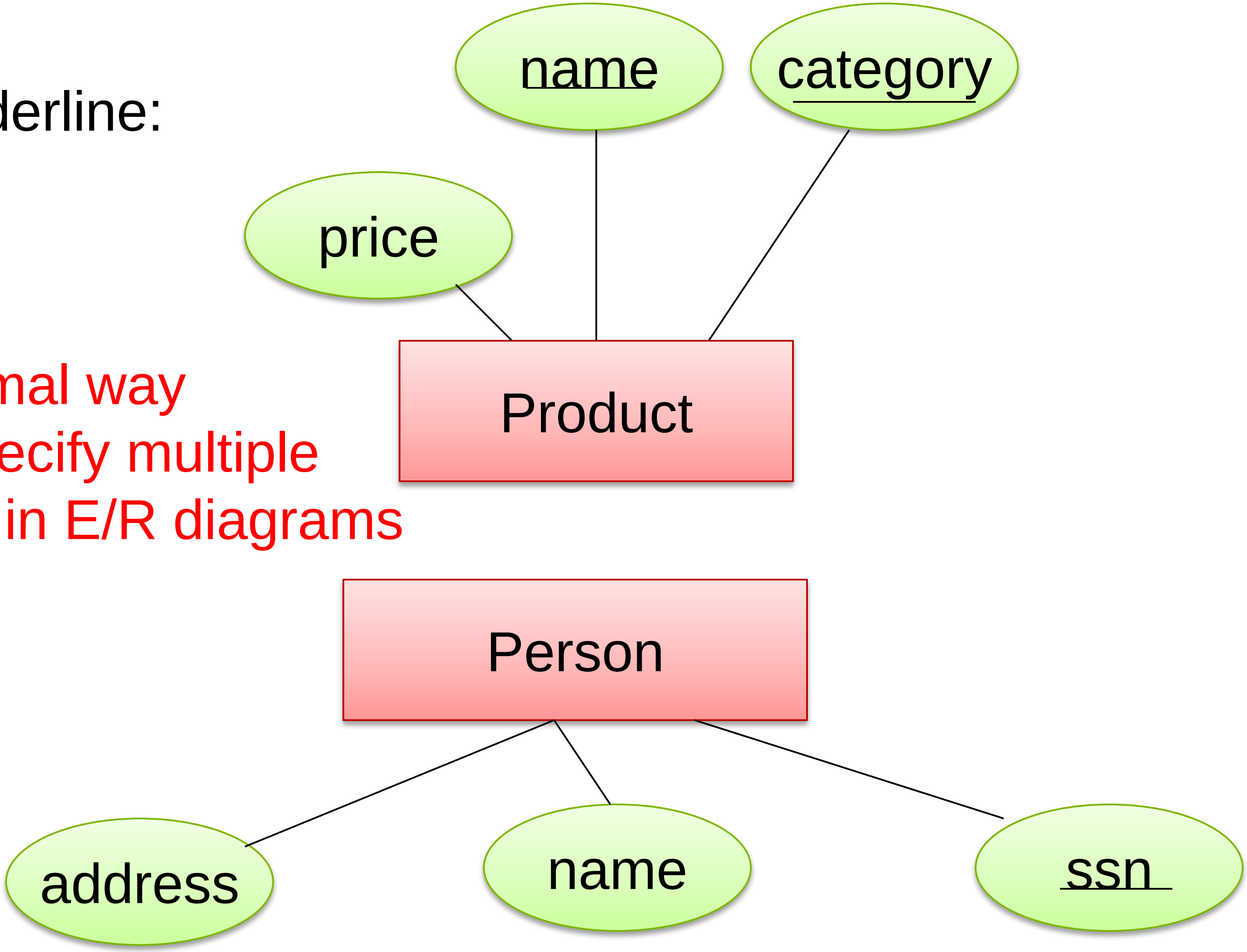
Single-value constraints: a person can have only one ssn

Referential integrity constraints: if you work for a company, it must exist in the database.

Other constraints: peoples' ages are between 0 and 150.

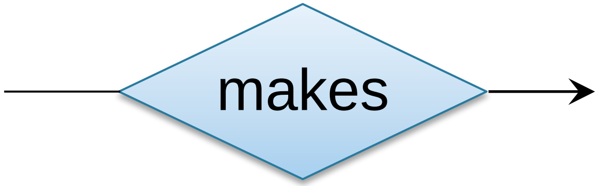
Keys in E/R Diagrams

Underline:

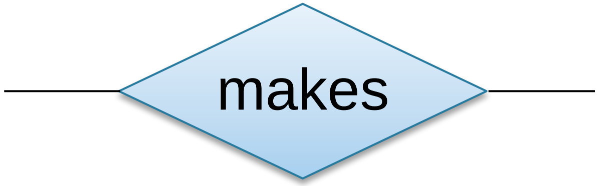


No formal way to specify multiple keys in E/R diagrams

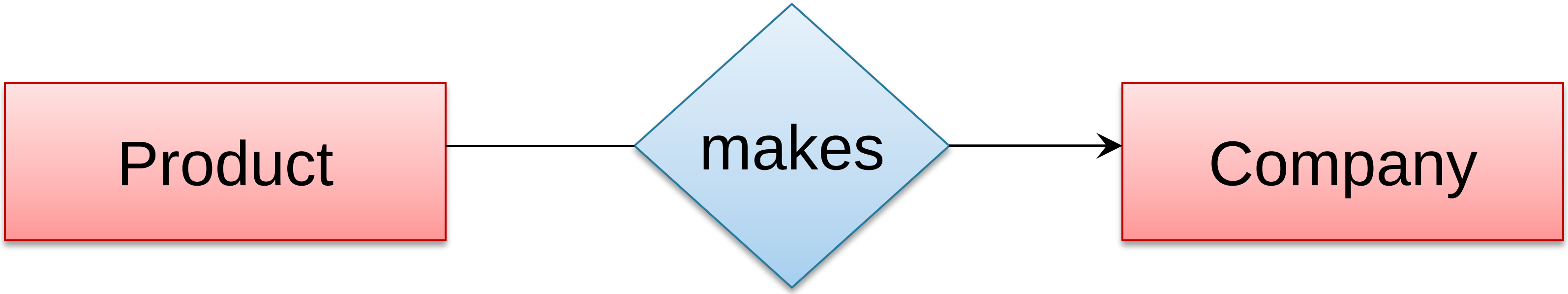
Single Value Constraints



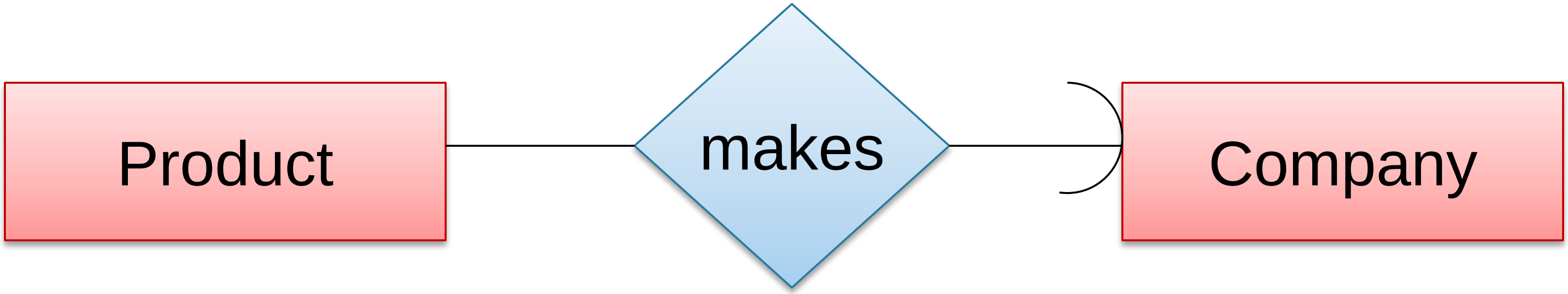
v. s.



Referential Integrity Constraints



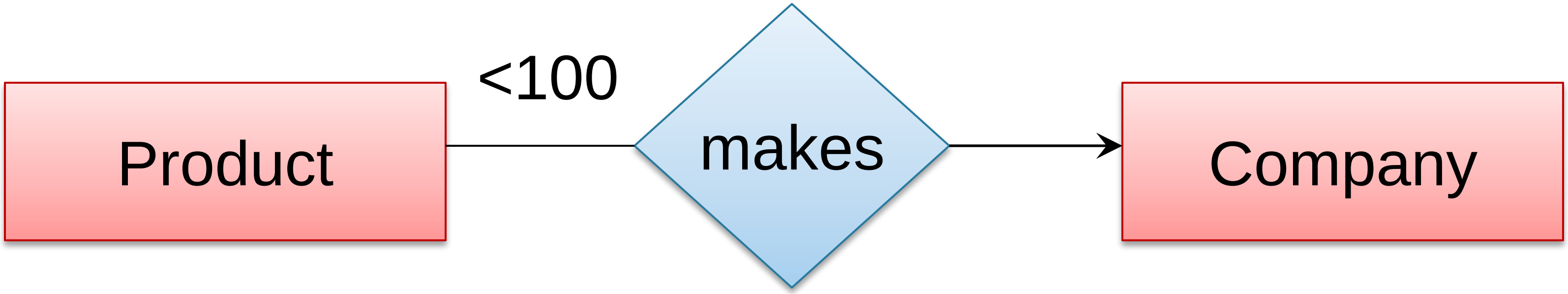
Each product made by at most one company.
Some products made by no company



Each product made by *exactly* one company.

Note: For weak entity sets → should be replaced by —)
(sec 4.4.2)

Other Constraints



Q: What does this mean ?
A: A Company entity cannot be connected
by relationship to more than 99 Product entities

Note: For “at least one”, you can use “≥ 1” in a many-many relationship