Introduction to Database Systems
CSE 414

Lecture 19: E/R Diagrams

Class Overview

- Unit 1: Intro
- Unit 2: Relational Data Models and Query Languages
- Unit 3: Non-relational data
- Unit 4: RDMBS internals and query optimization
- Unit 5: Parallel query processing
- Unit 6: DBMS usability, conceptual design
  - E/R diagrams
  - Schema normalization
- Unit 7: Transactions

Database Design

What it is:

- Starting from scratch, design the database schema: relation, attributes, keys, foreign keys, constraints etc

Why it's hard

- The database will be in operation for a very long time (years). Updating the schema while in production is very expensive (why?)

Database Design

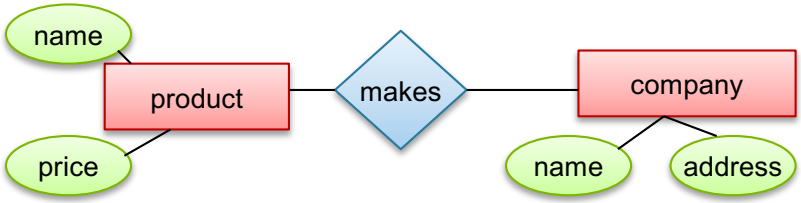
- Consider issues such as:
  - What entities to model
  - How entities are related
  - What constraints exist in the domain

- Several formalisms exists
  - We discuss E/R diagrams
  - UML, model-driven architecture

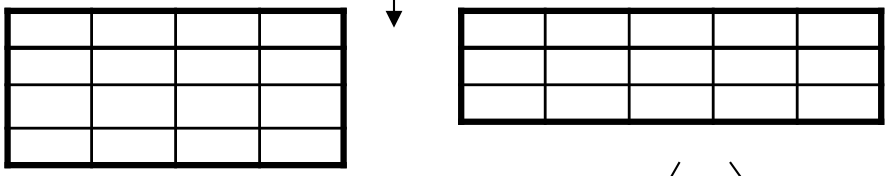
- Reading: Sec. 4.1-4.6

Database Design Process

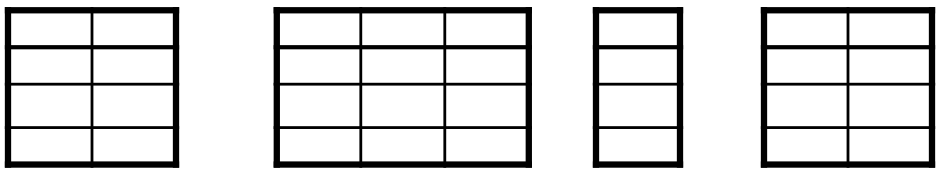
Conceptual Model:



Relational Model:
Tables + constraints
And also functional dep.

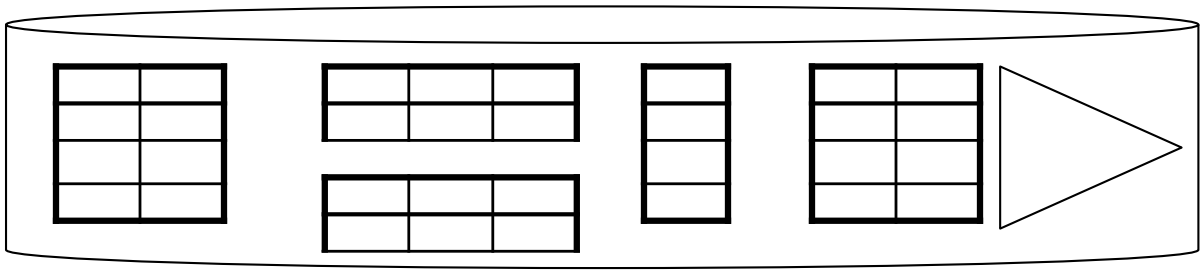


Normalization:
Eliminates anomalies



Conceptual Schema

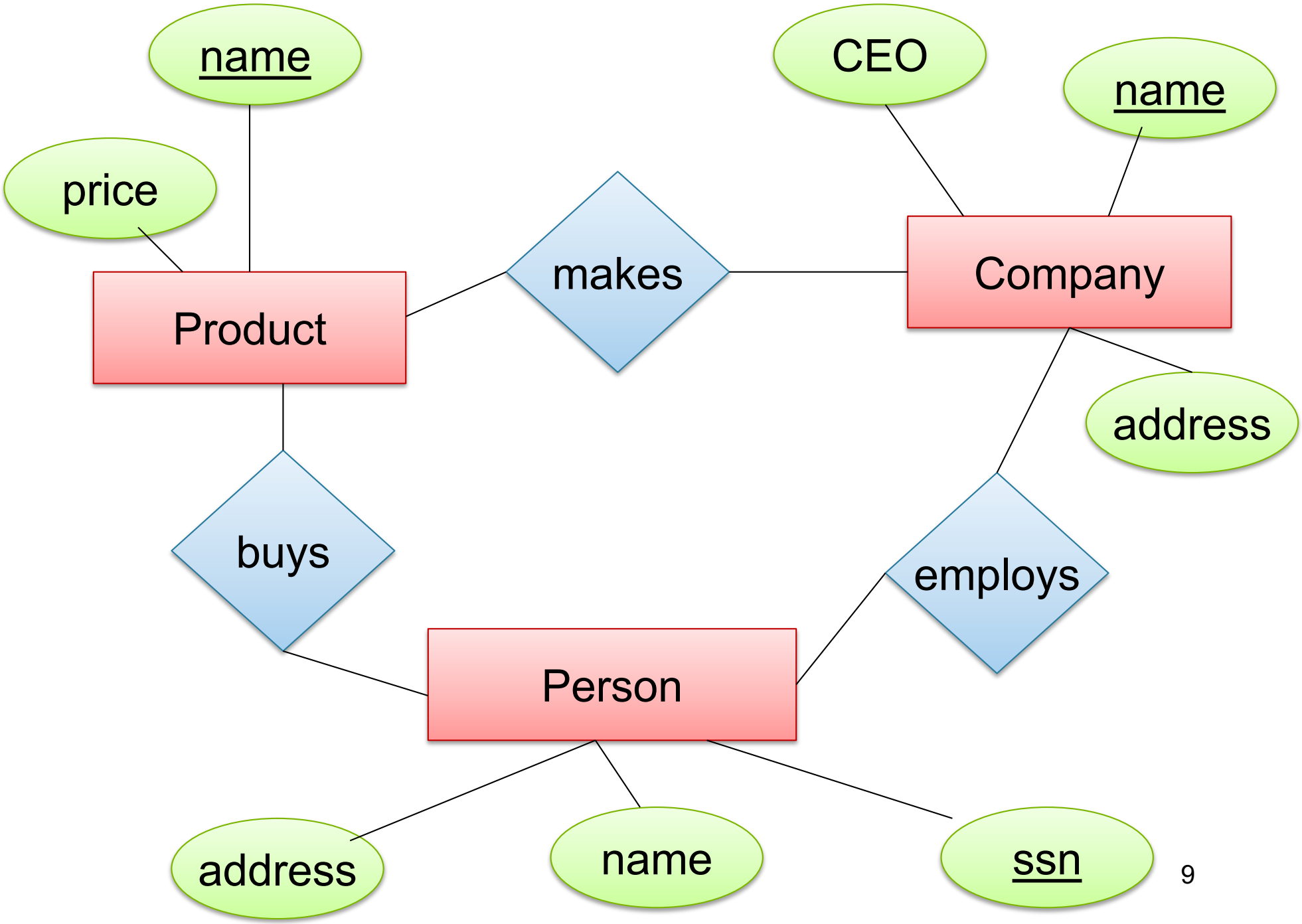
Physical storage details



Physical Schema

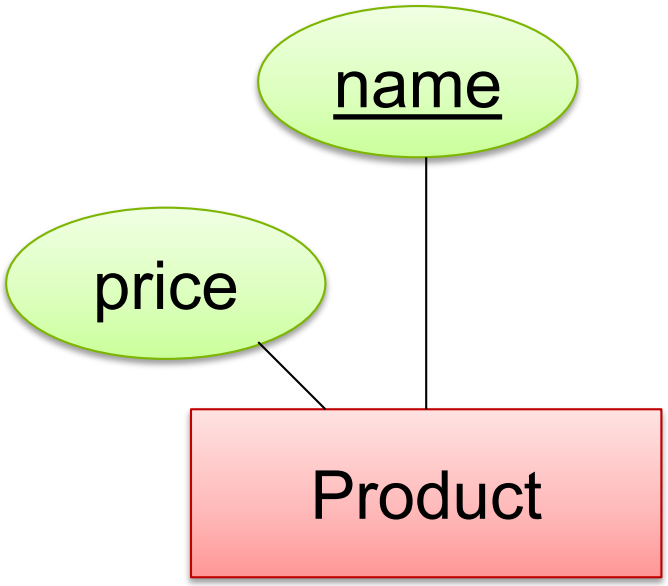
Entity / Relationship Diagrams

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


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

Keys in E/R Diagrams

- Every entity set must have a key

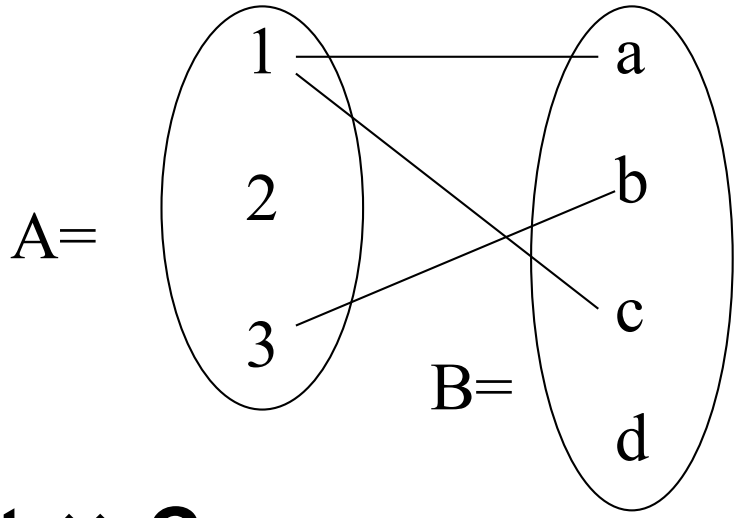


What is a Relation ?

- 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)}

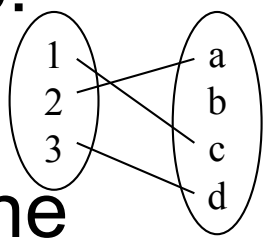
  R = {(1,a), (1,c), (3,b)}

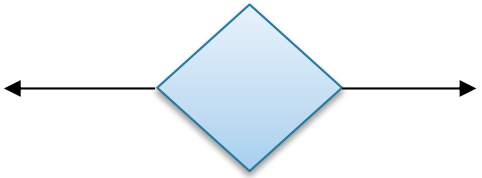


- **makes** is a subset of **Product × Company**:

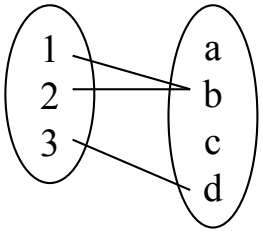
Multiplicity of E/R Relations

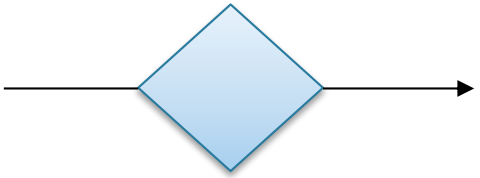
- one-one:



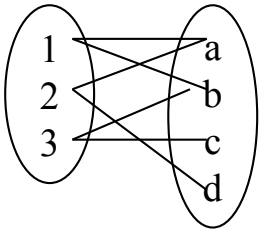


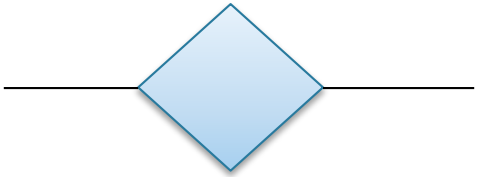
- many-one

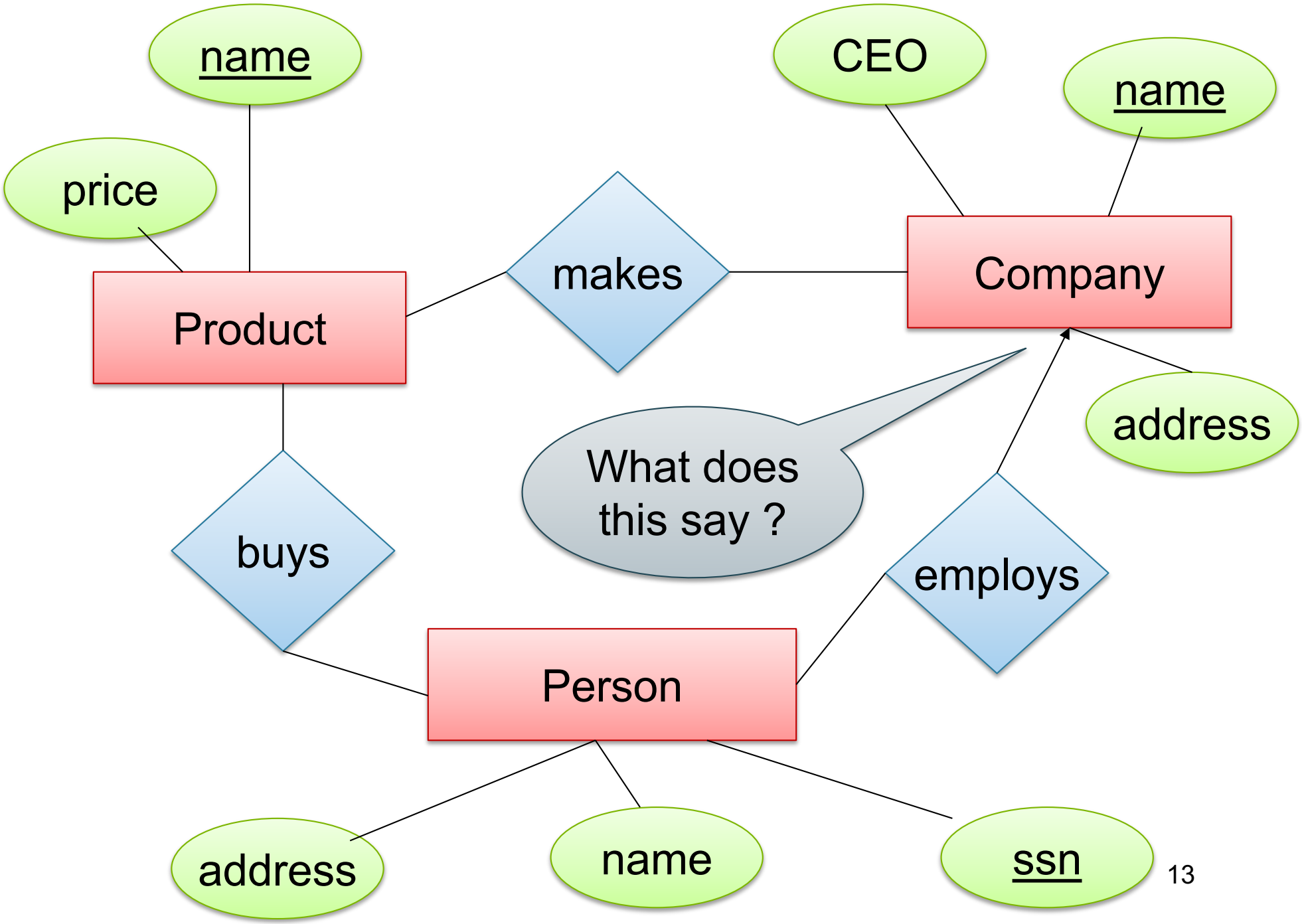




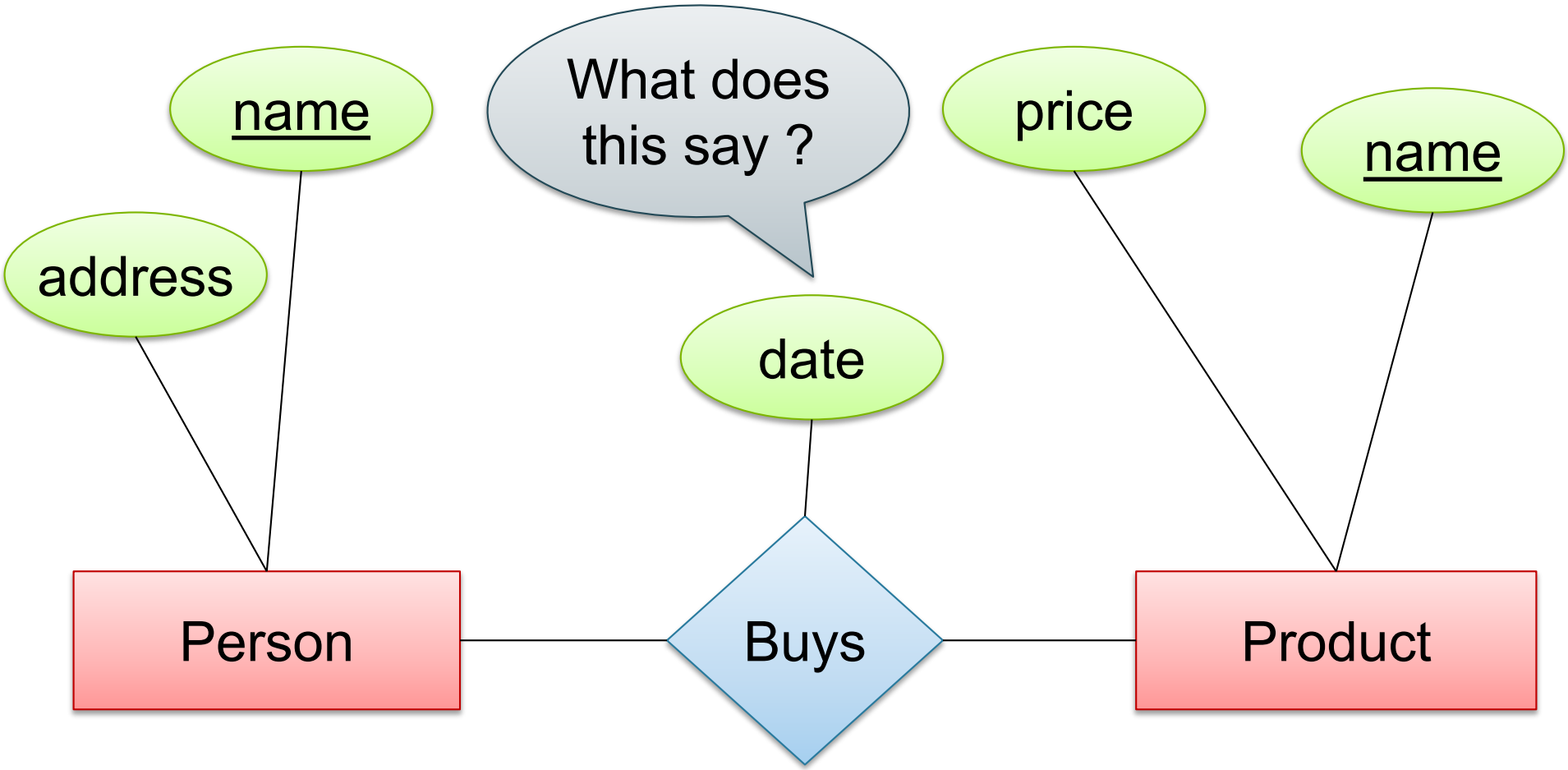
- many-many





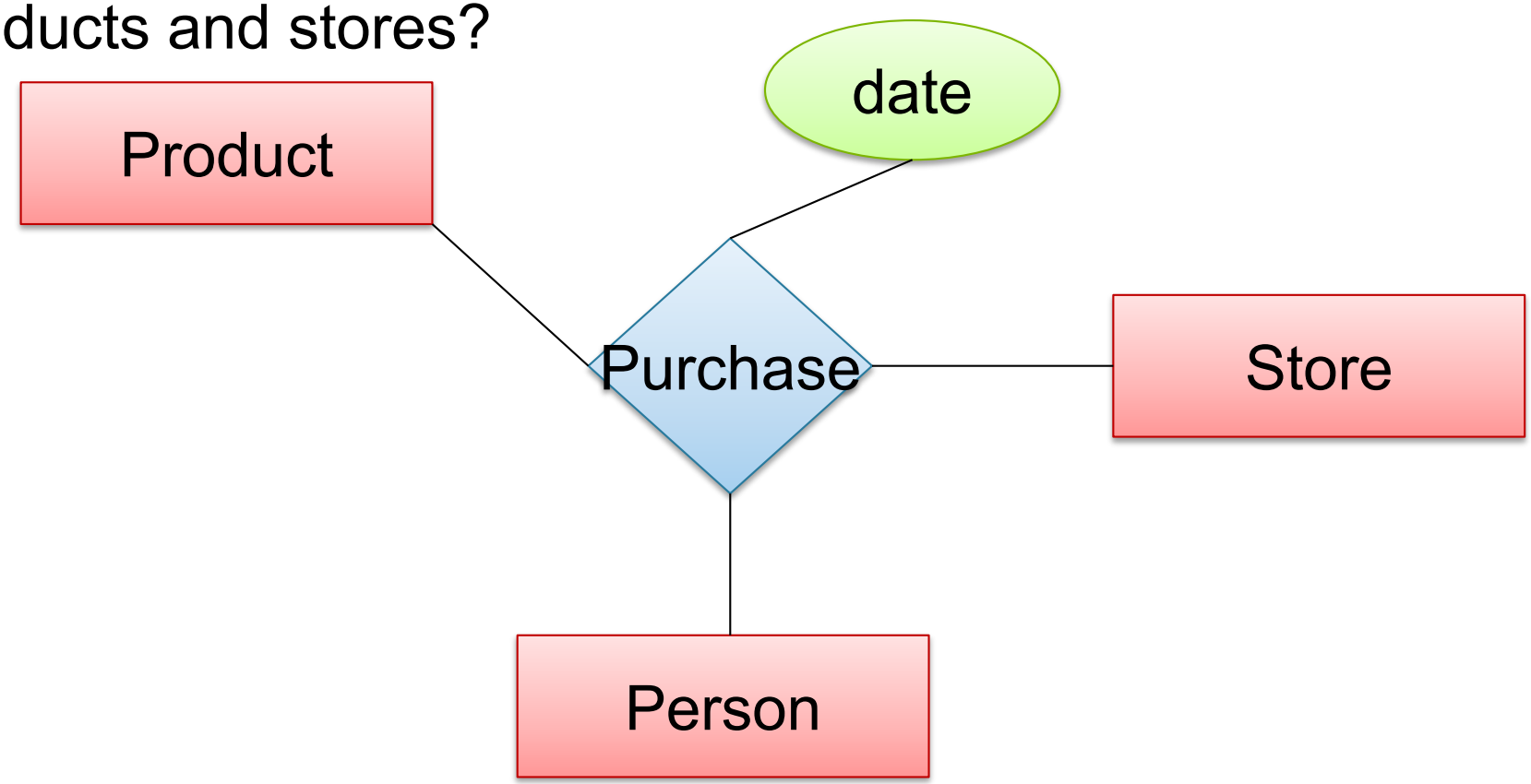

name
CEO
name
price
makes
Company
Product
address
What does this say ?
buys
employs
Person
address
name
ssn

Attributes on Relationships



Multi-way Relationships

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

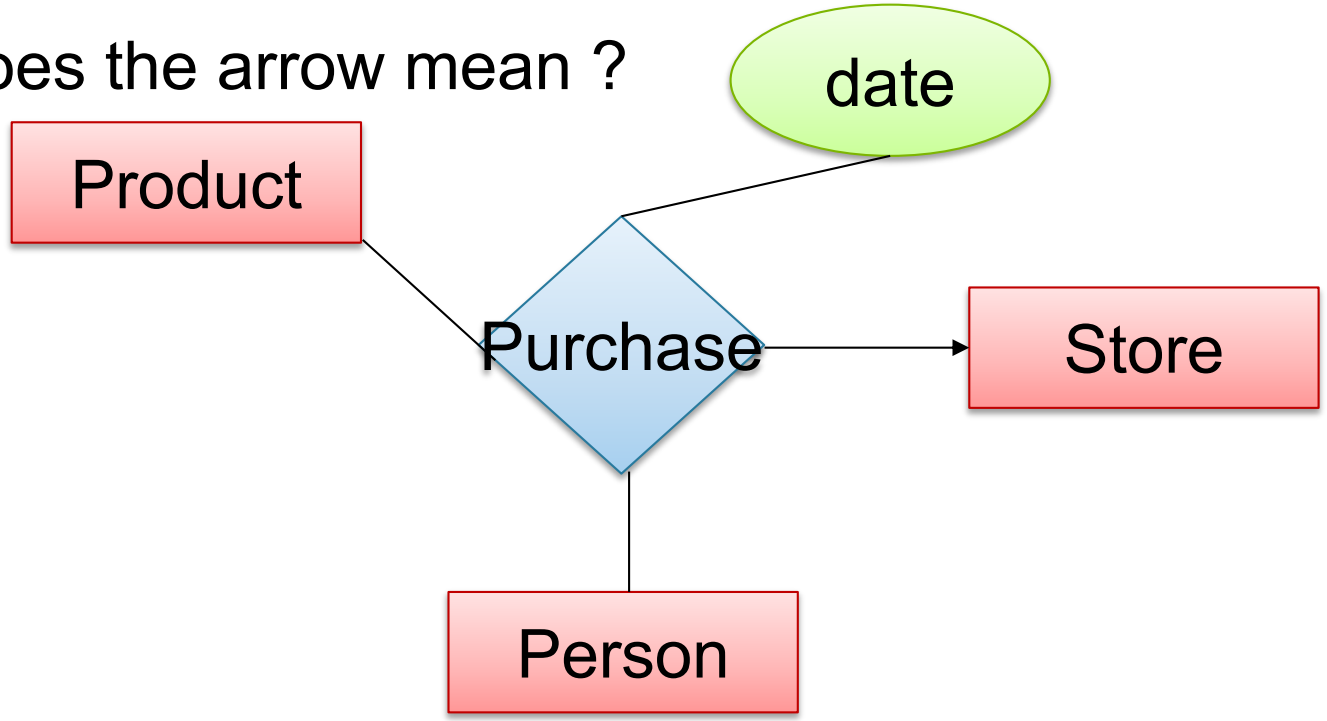


Can still model as a mathematical set (How?)

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

Arrows in Multiway Relationships

Q: What does the arrow mean ?

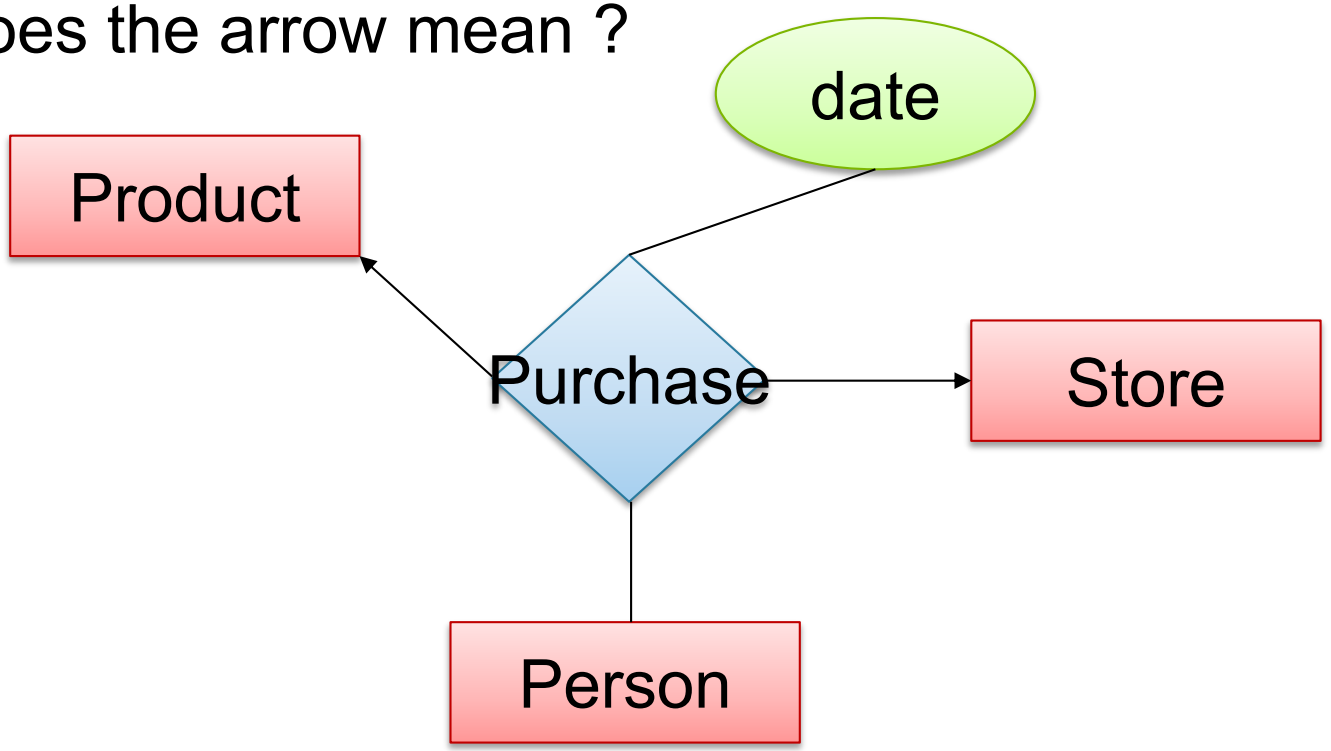


A: Any person buys a given product from at most one store

[Fine print: 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]

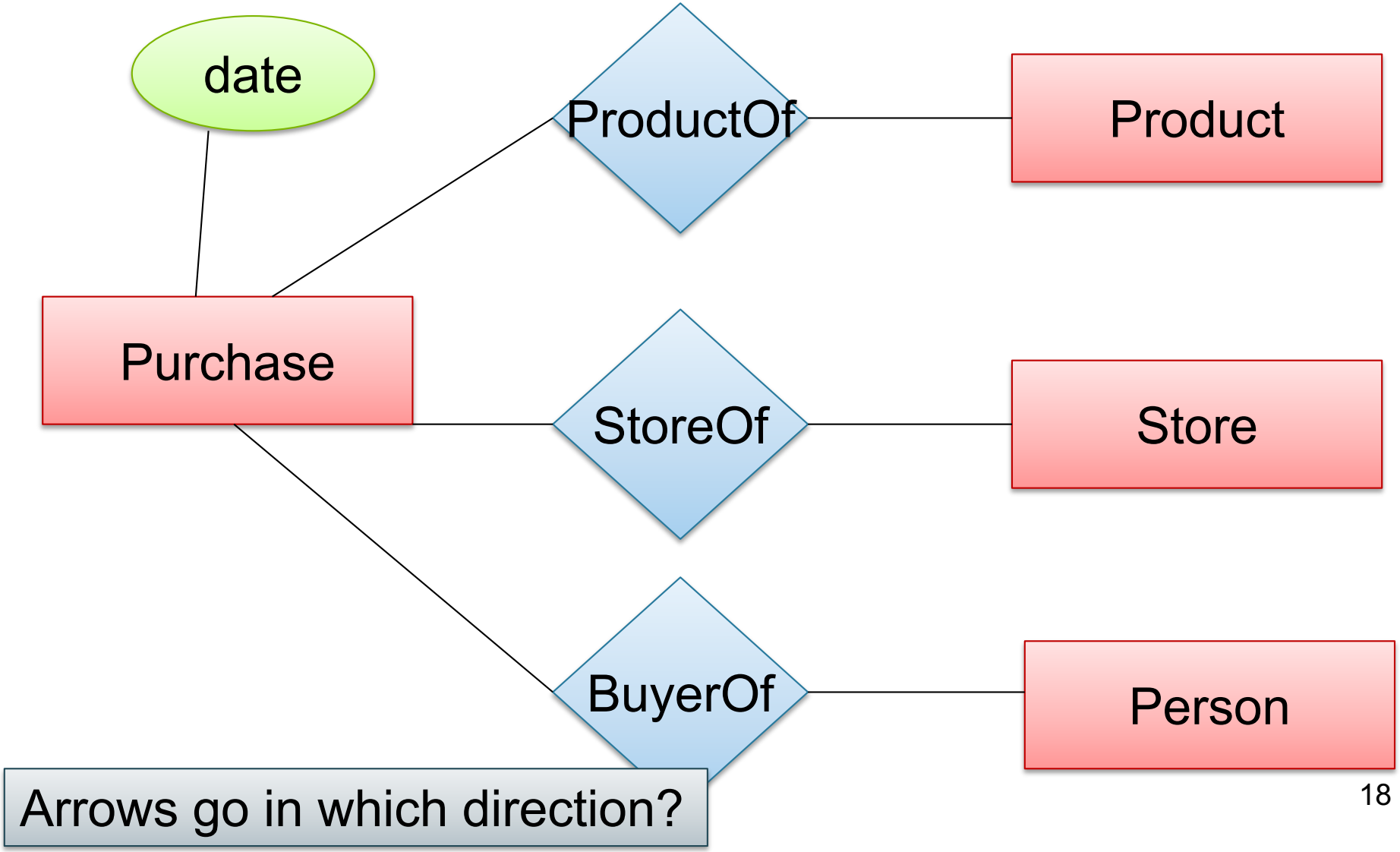
Arrows in Multiway Relationships

Q: What does the arrow mean ?

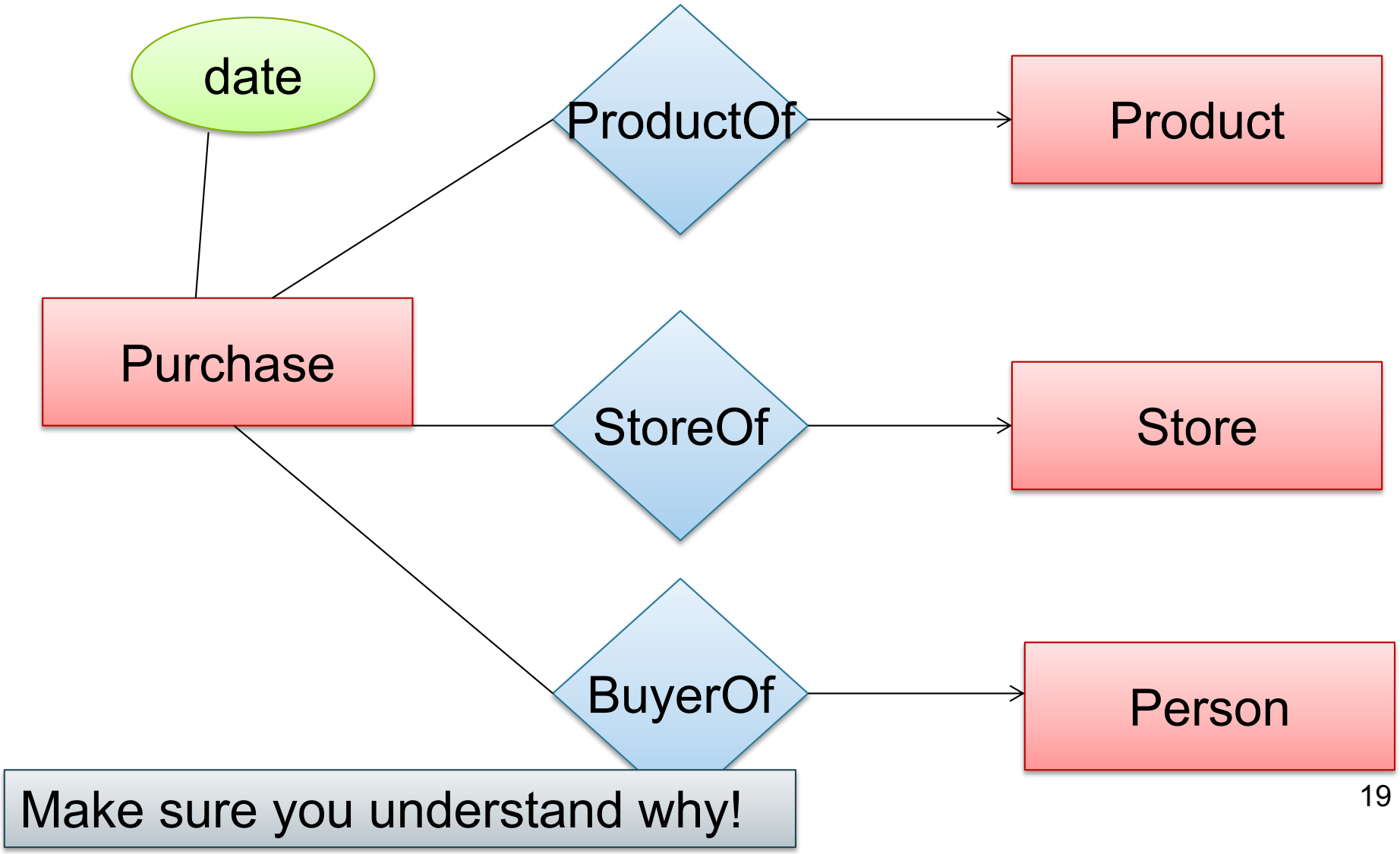


A: Any person buys a given product from at most one store AND every store sells to every person at most one product

Converting Multi-way Relationships to Binary

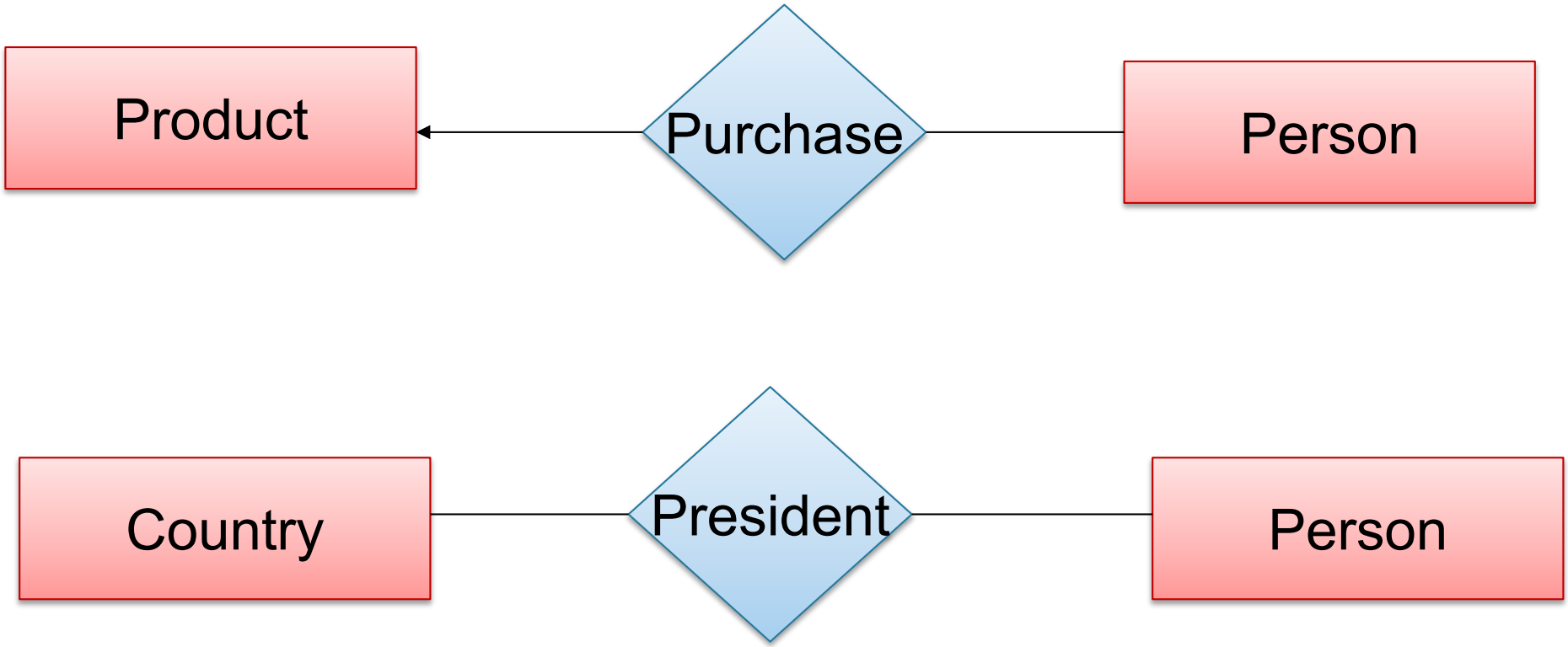


Converting Multi-way Relationships to Binary



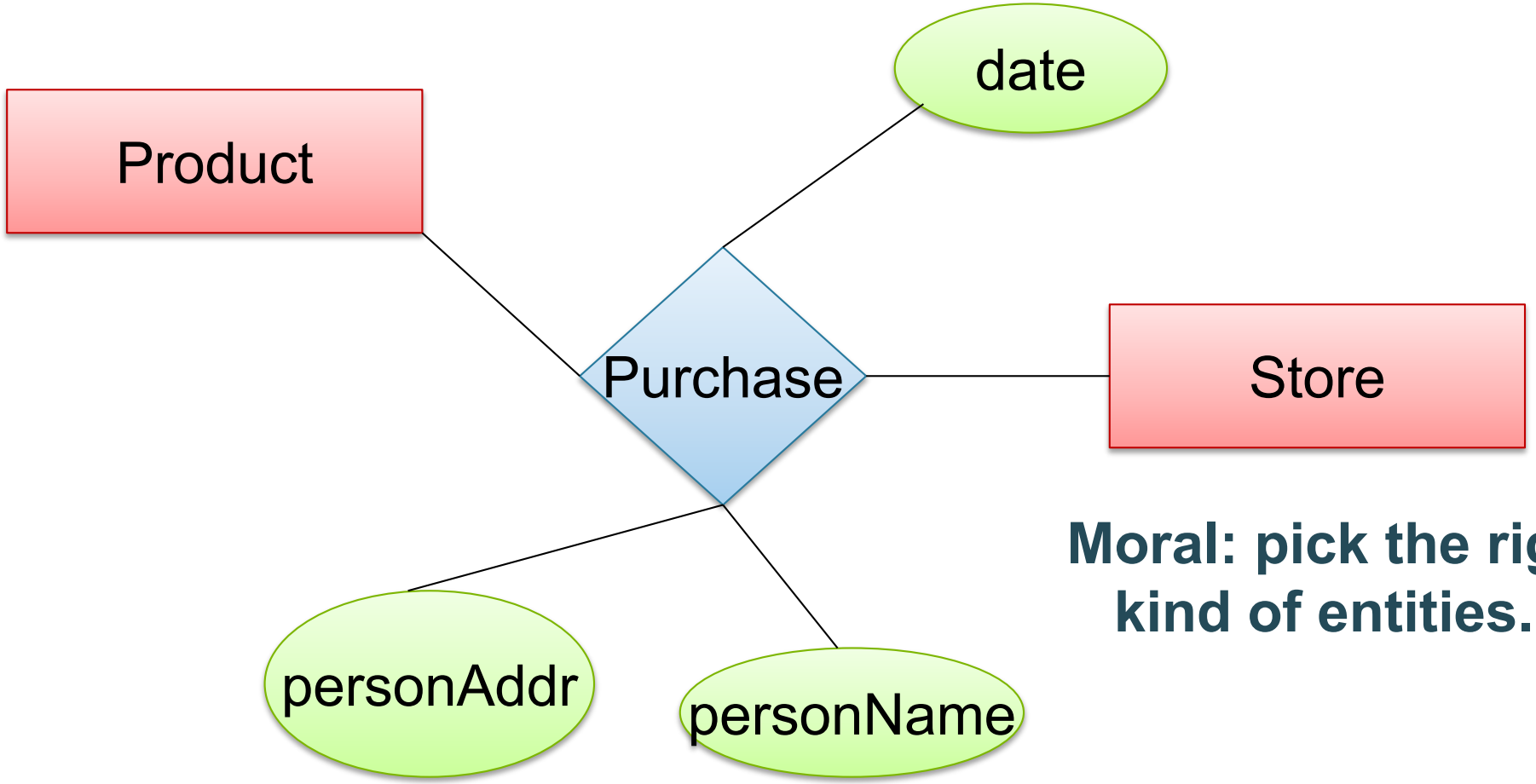
3. Design Principles

What's wrong?



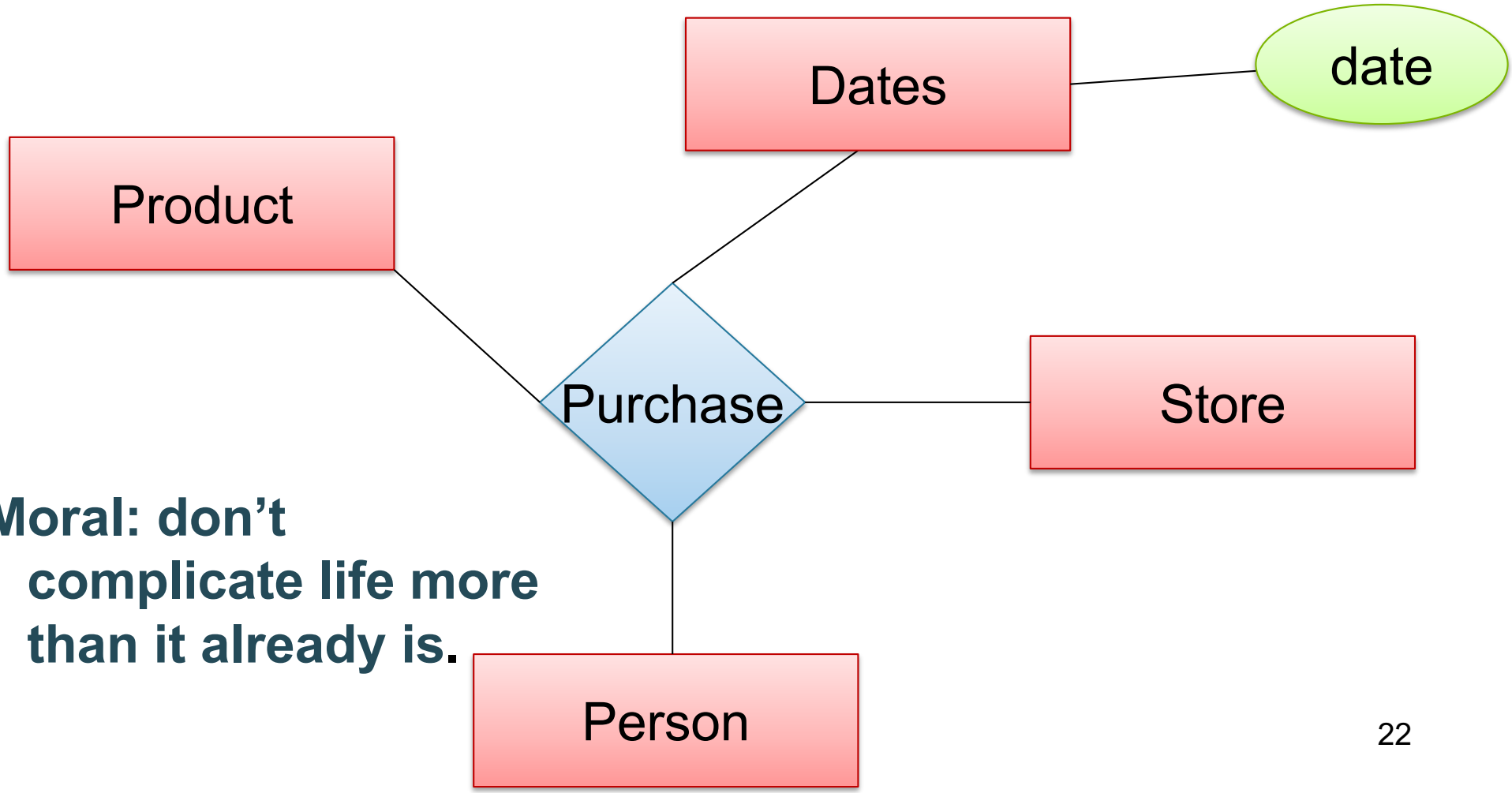
Moral: Be faithful to the specifications of the application!

Design Principles: What's Wrong?



Moral: pick the right kind of entities.

Design Principles: What's Wrong?

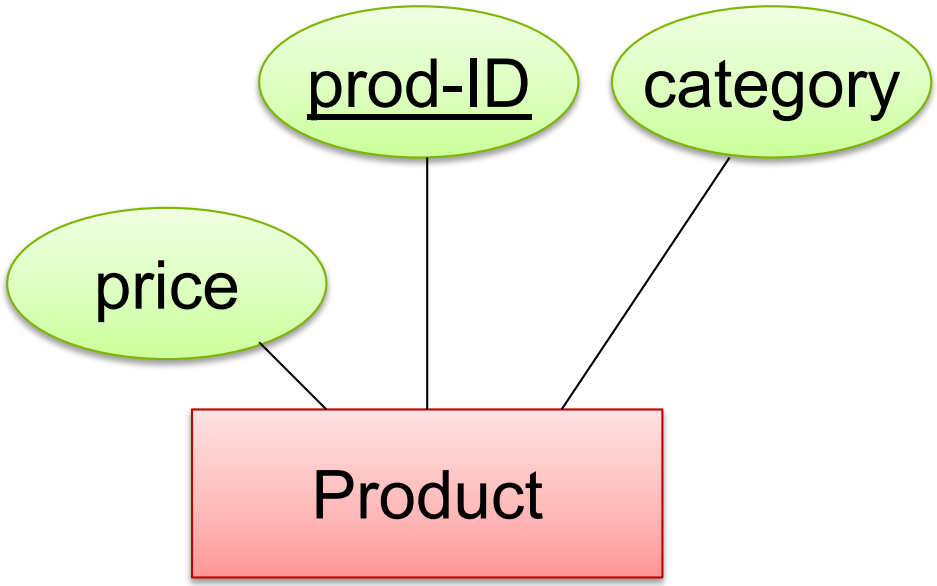


Moral: don't complicate life more than it already is.

From E/R Diagrams to Relational Schema

- Entity set → relation
- Relationship → relation

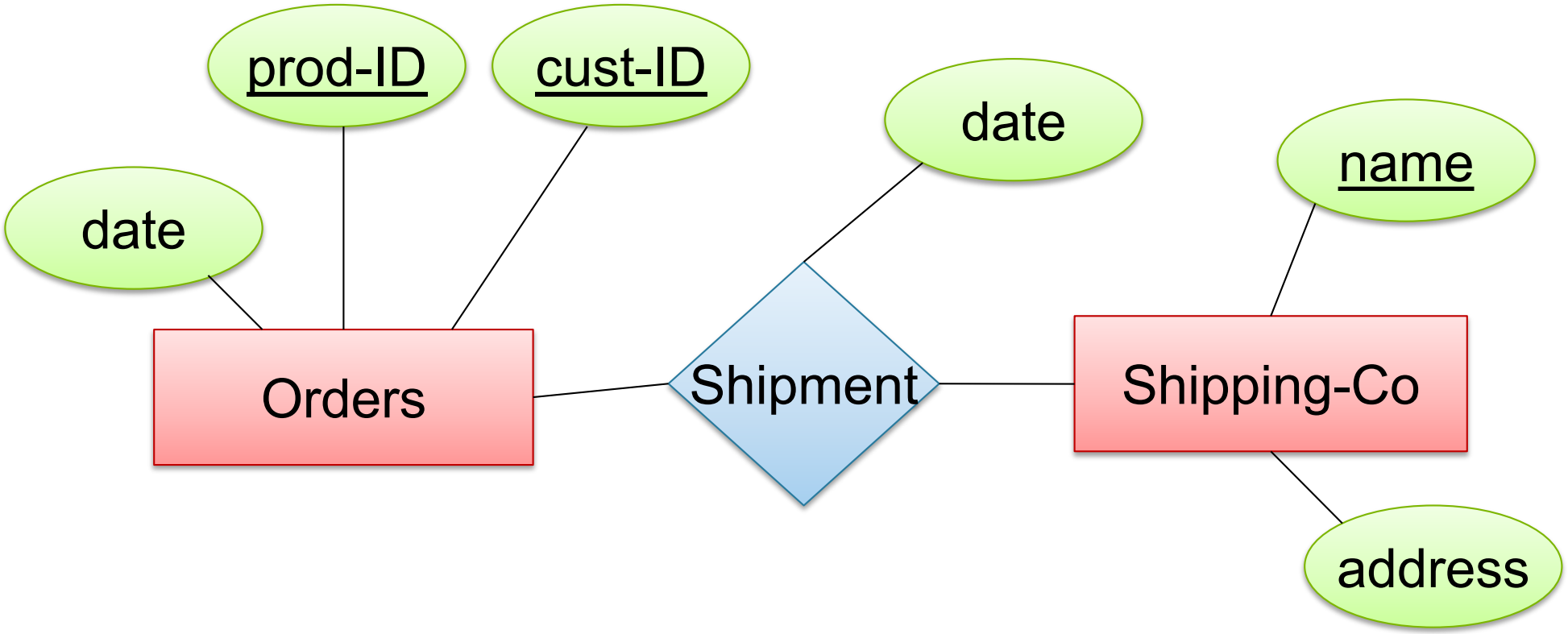
Entity Set to Relation



Product(prod-ID, category, price)

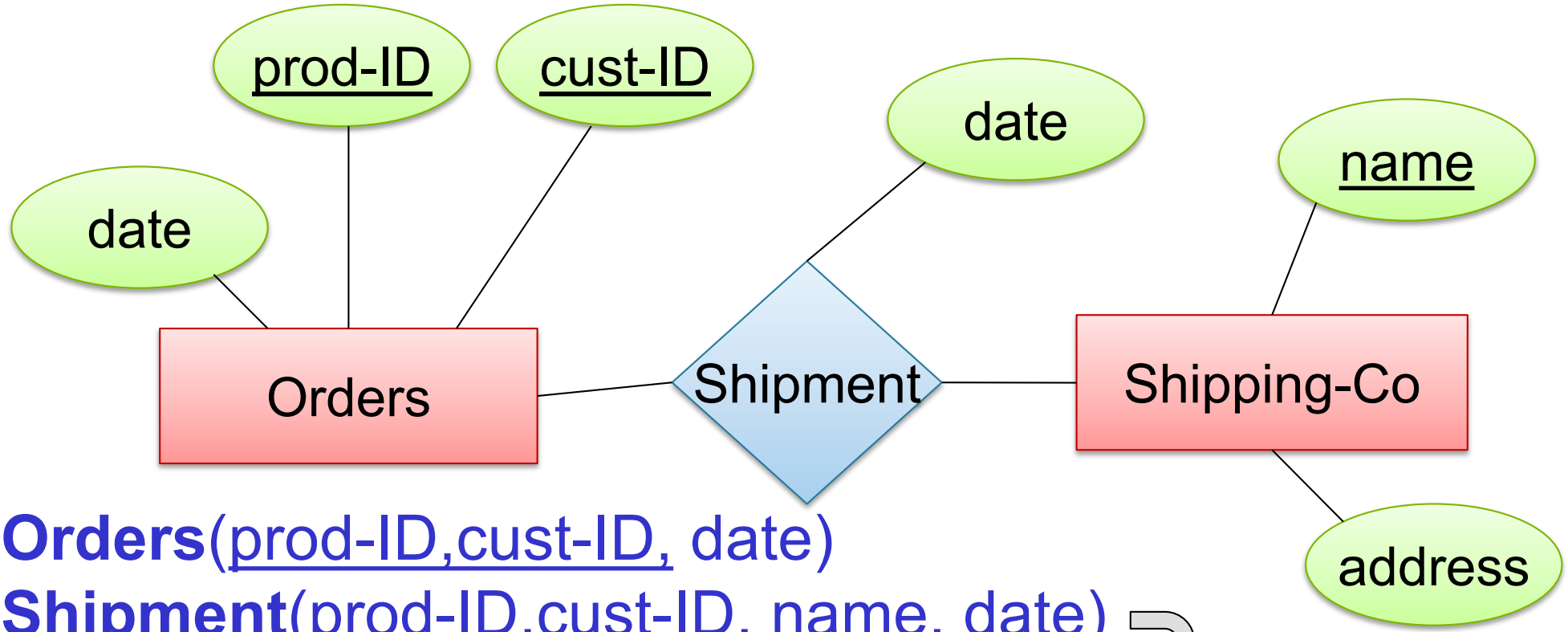
prod-ID	category	price
Gizmo55	Camera	99.99
Pokemn19	Toy	29.99

N-N Relationships to Relations



Represent this in relations

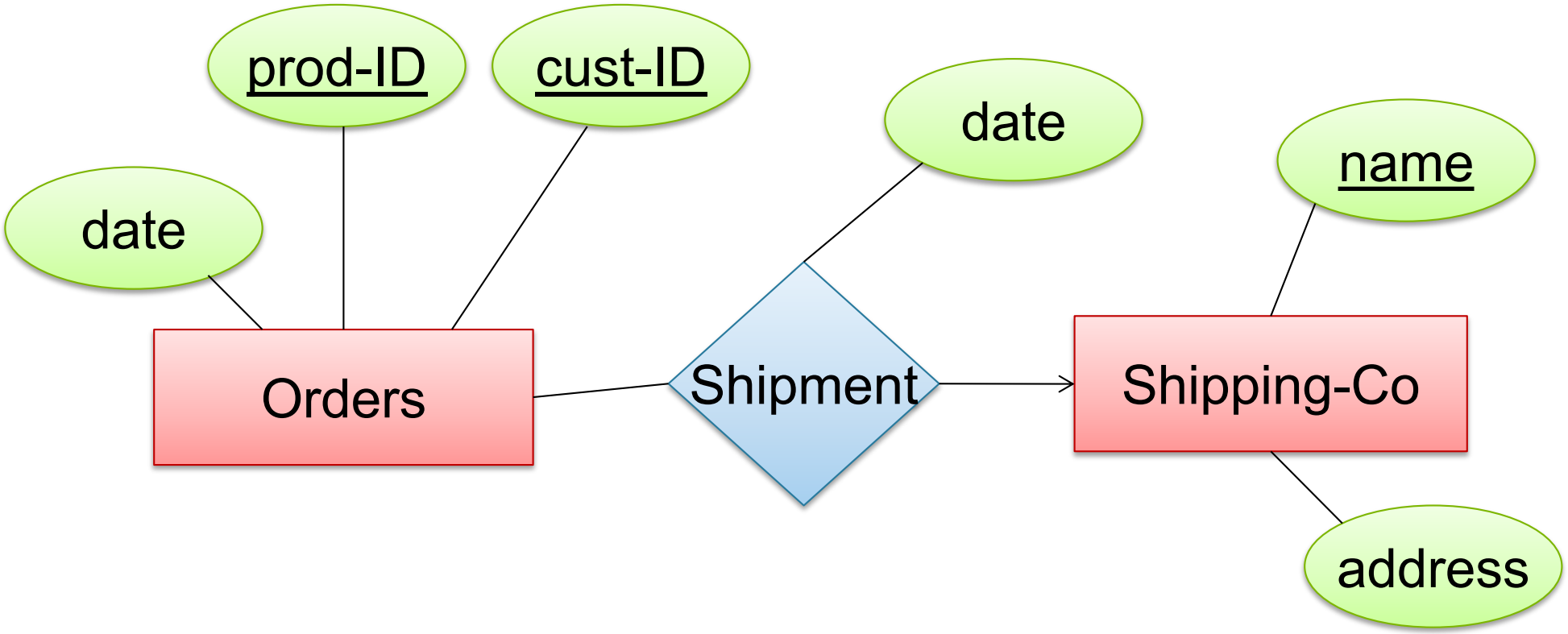
N-N Relationships to Relations



Orders(prod-ID,cust-ID, date)
Shipment(prod-ID,cust-ID, name, date)
Shipping-Co(name, address)

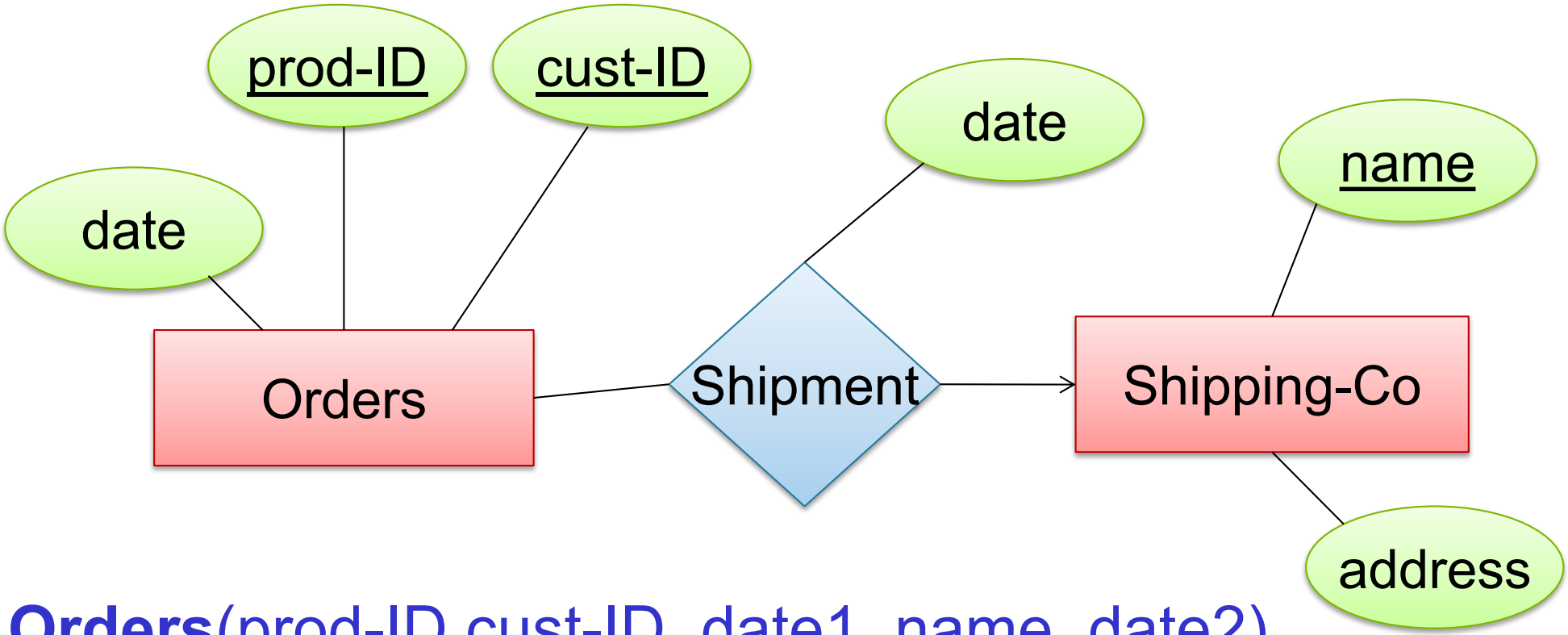
prod-ID	cust-ID	name	date
Gizmo55	Joe12	UPS	4/10/2011
Gizmo55	Joe12	FEDEX	4/9/2011

N-1 Relationships to Relations



Represent this in relations

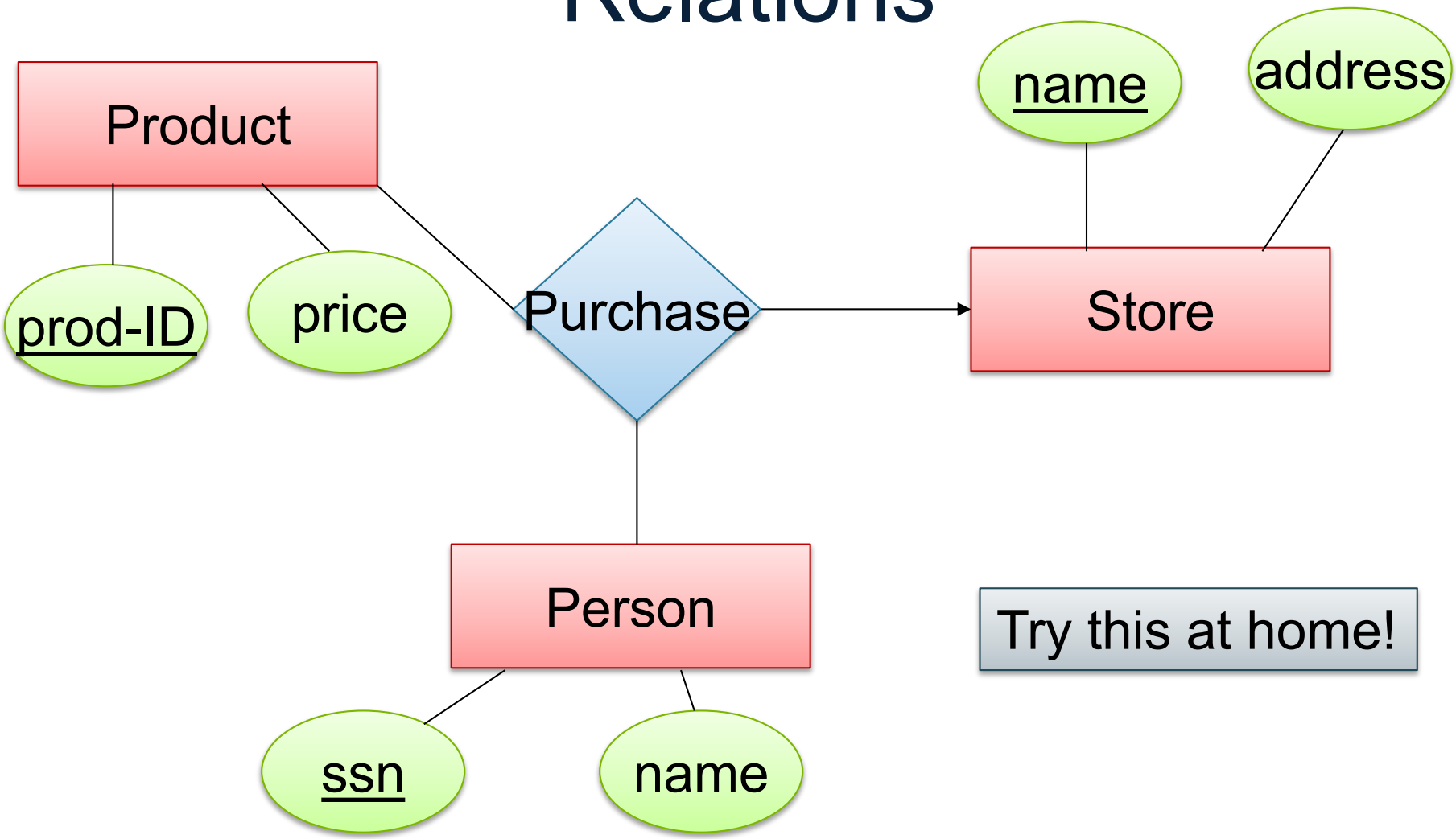
N-1 Relationships to Relations



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

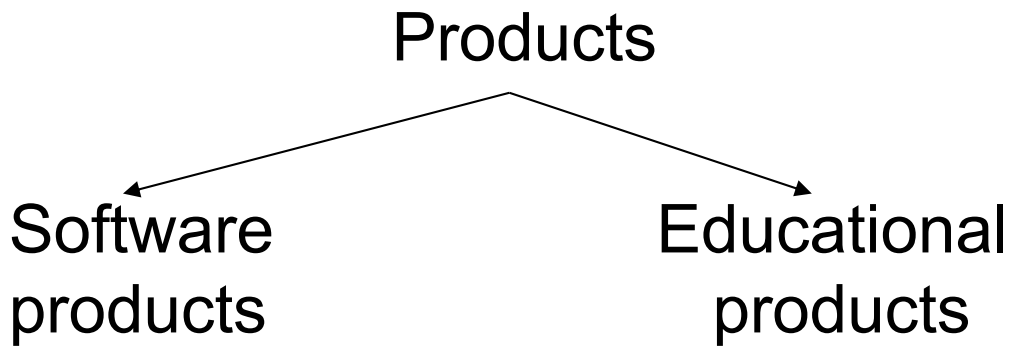


Purchase(prod-ID, ssn, name)

Modeling Subclasses

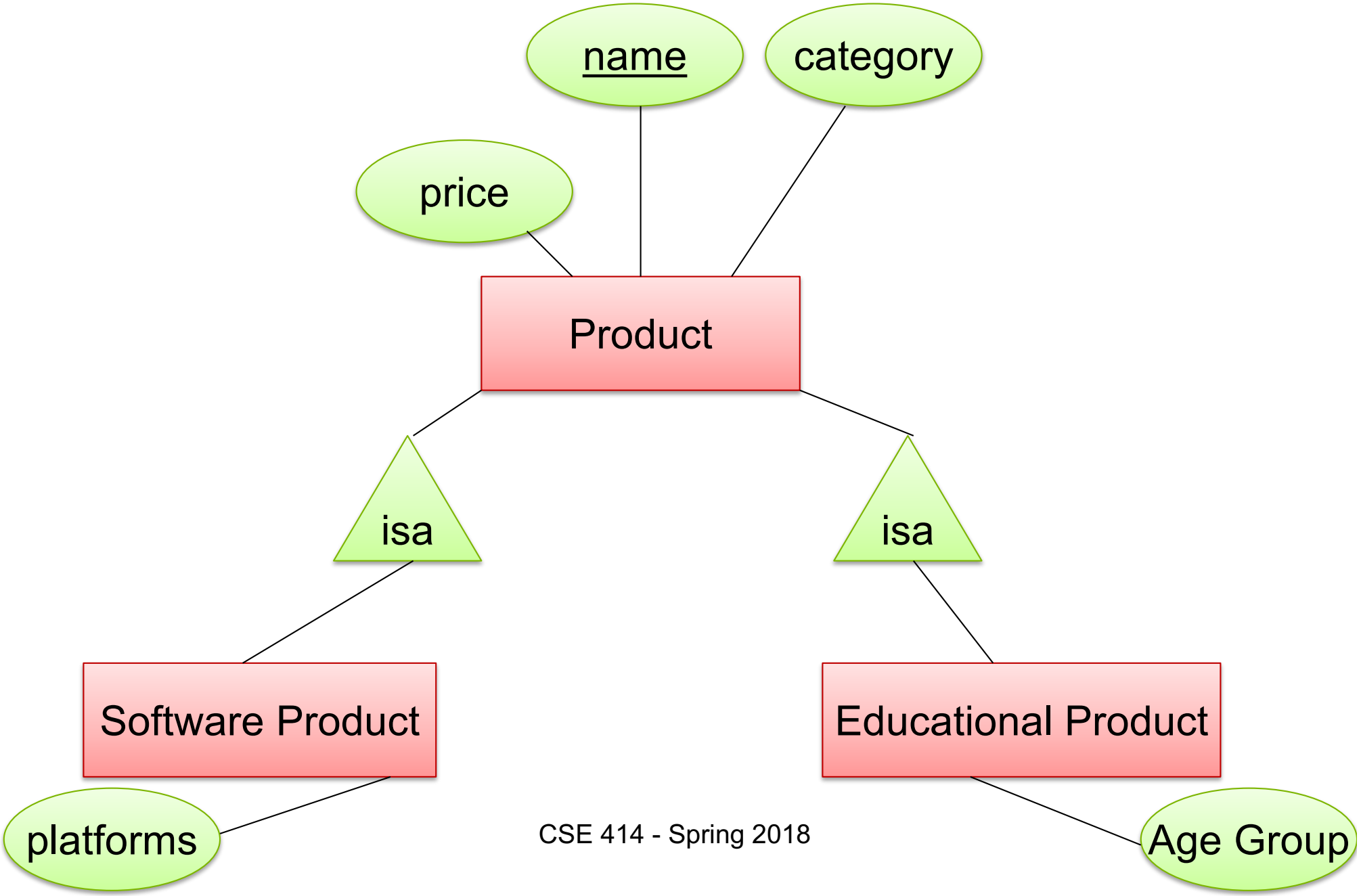
Some objects in a class may be special

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

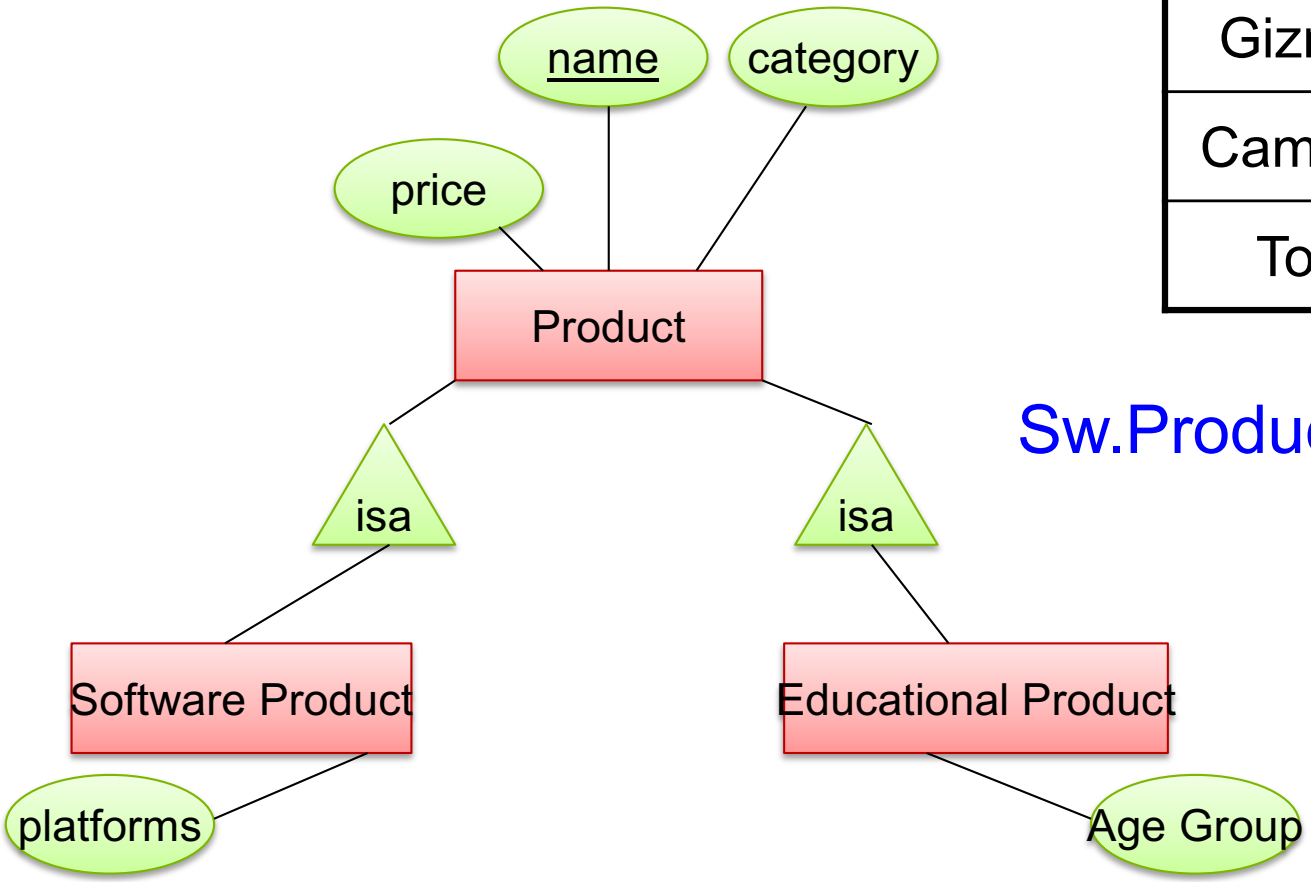


So --- we define subclasses in E/R

Subclasses


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

Subclasses to Relations



Product

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

Sw.Product

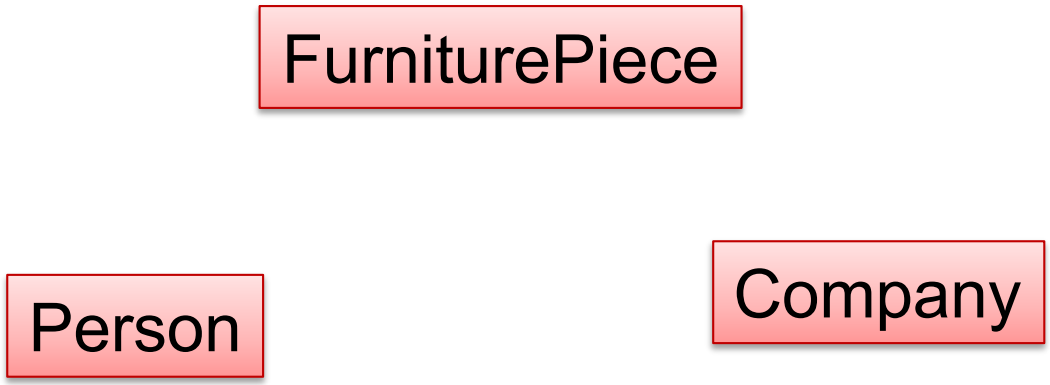
Name	platforms
Gizmo	unix

Ed.Product

Name	Age Group
Gizmo	toddler
Toy	retired

Other ways to convert are possible

Modeling Union Types with Subclasses

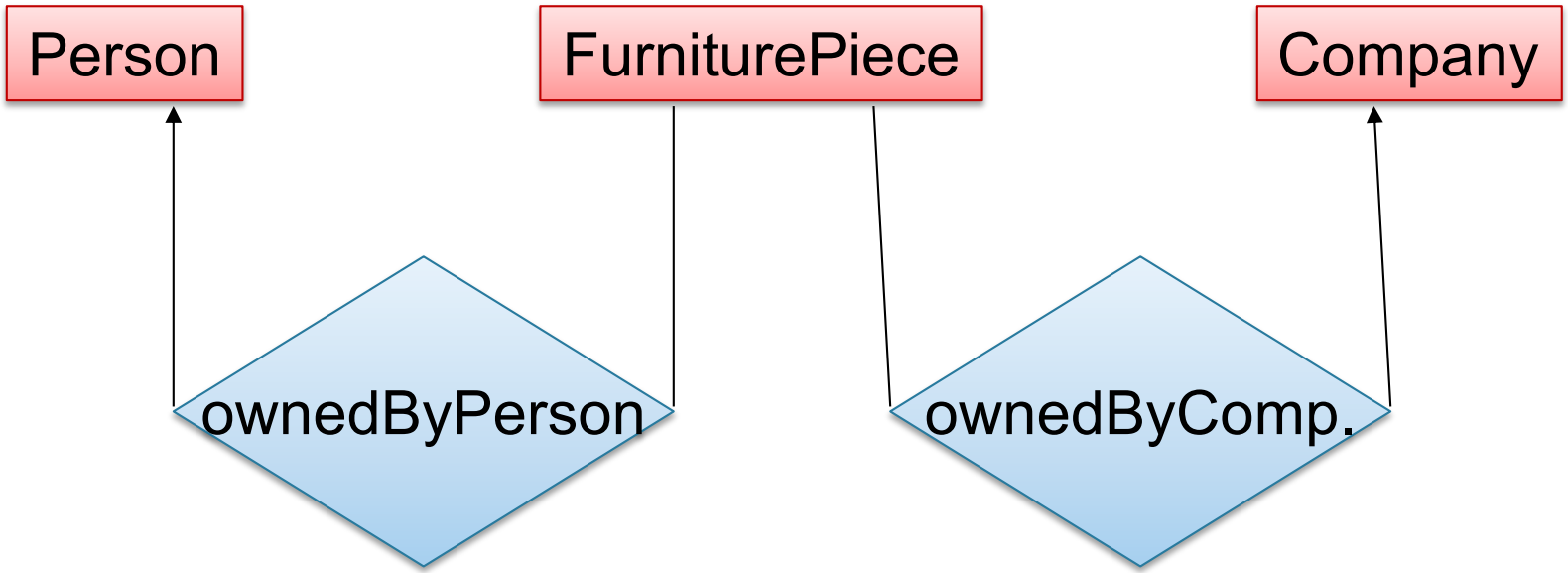


Say: each piece of furniture is owned either by a person or by a company

Modeling Union Types with Subclasses

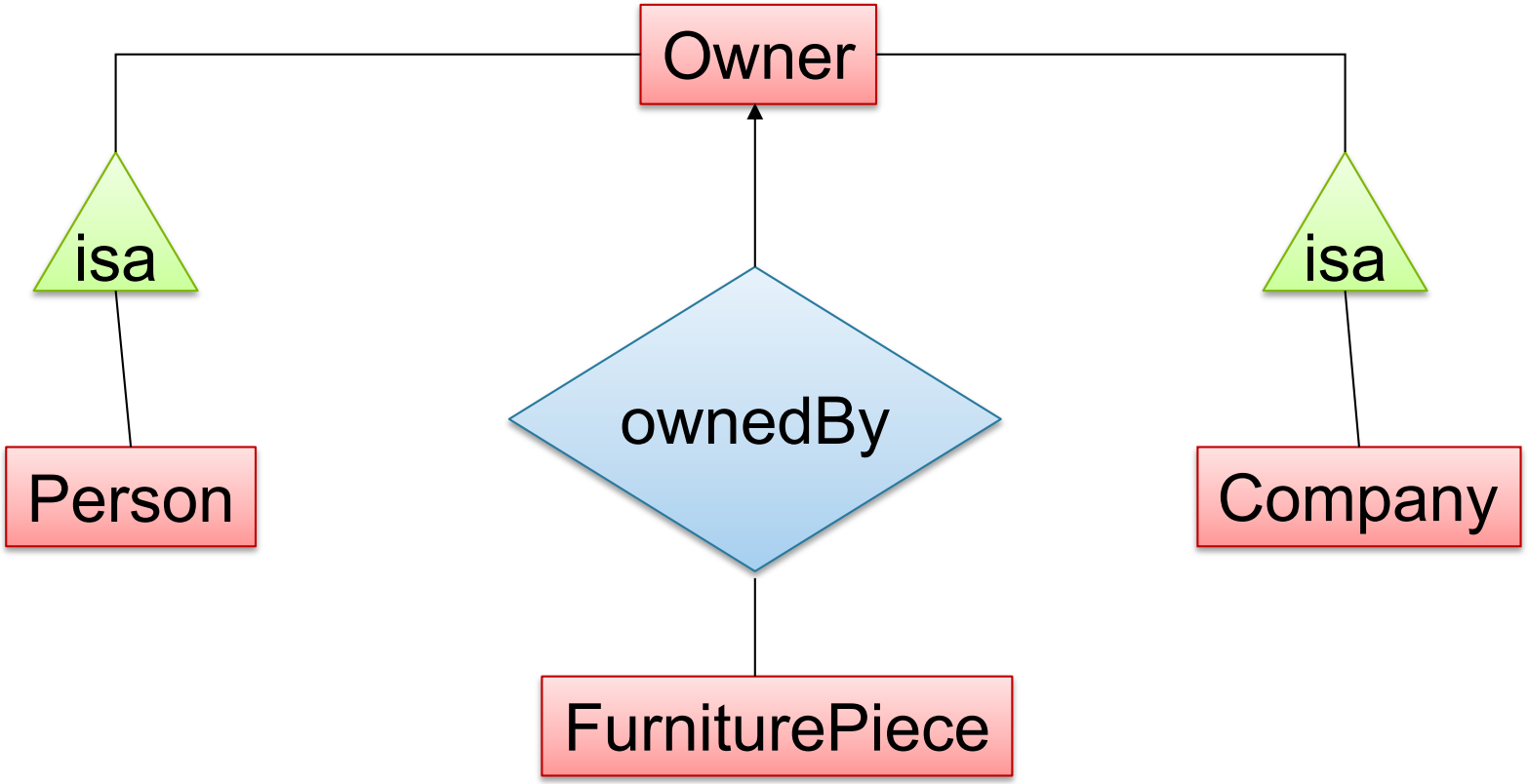
Say: each piece of furniture is owned either by a person or by a company

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



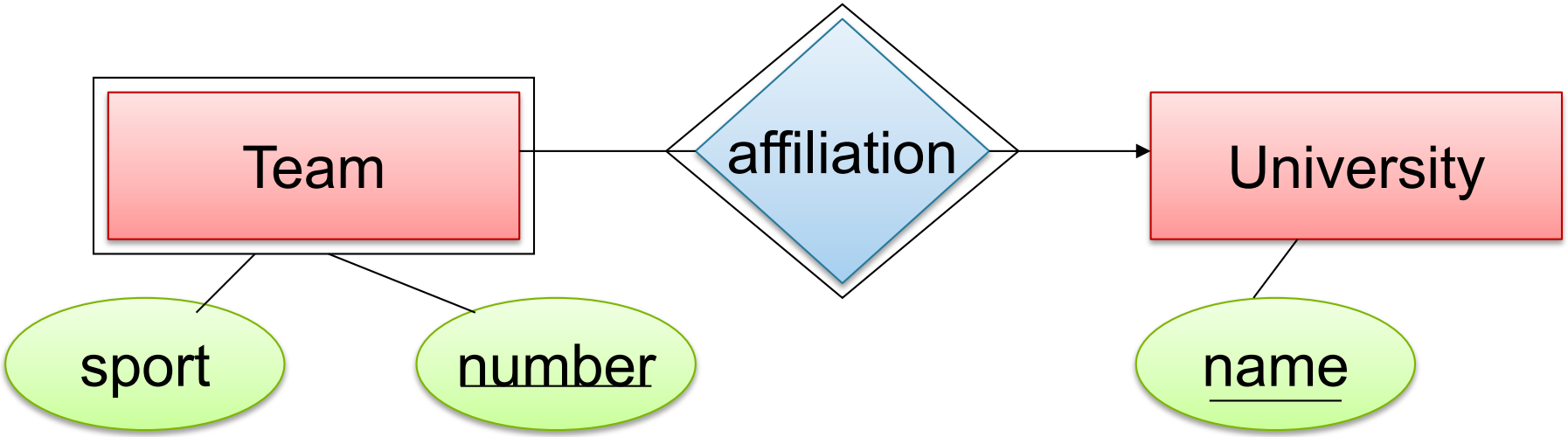
Modeling Union Types with Subclasses

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>)