Introduction to Data Management
CSE 414

Unit 6: Conceptual Design

E/R Diagrams

Integrity Constraints

BCNF

(3 lectures)

Introduction to Data Management CSE 414

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
- Unit 8: Advanced topics (time permitting)

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

ER 2017

The 36th International Conference on Conceptual Modeling

Nov. 6th-9th, 2017, Valencia Spain

- Reading: Sec. 4.1-4.6

Database Design Process

Conceptual Model:

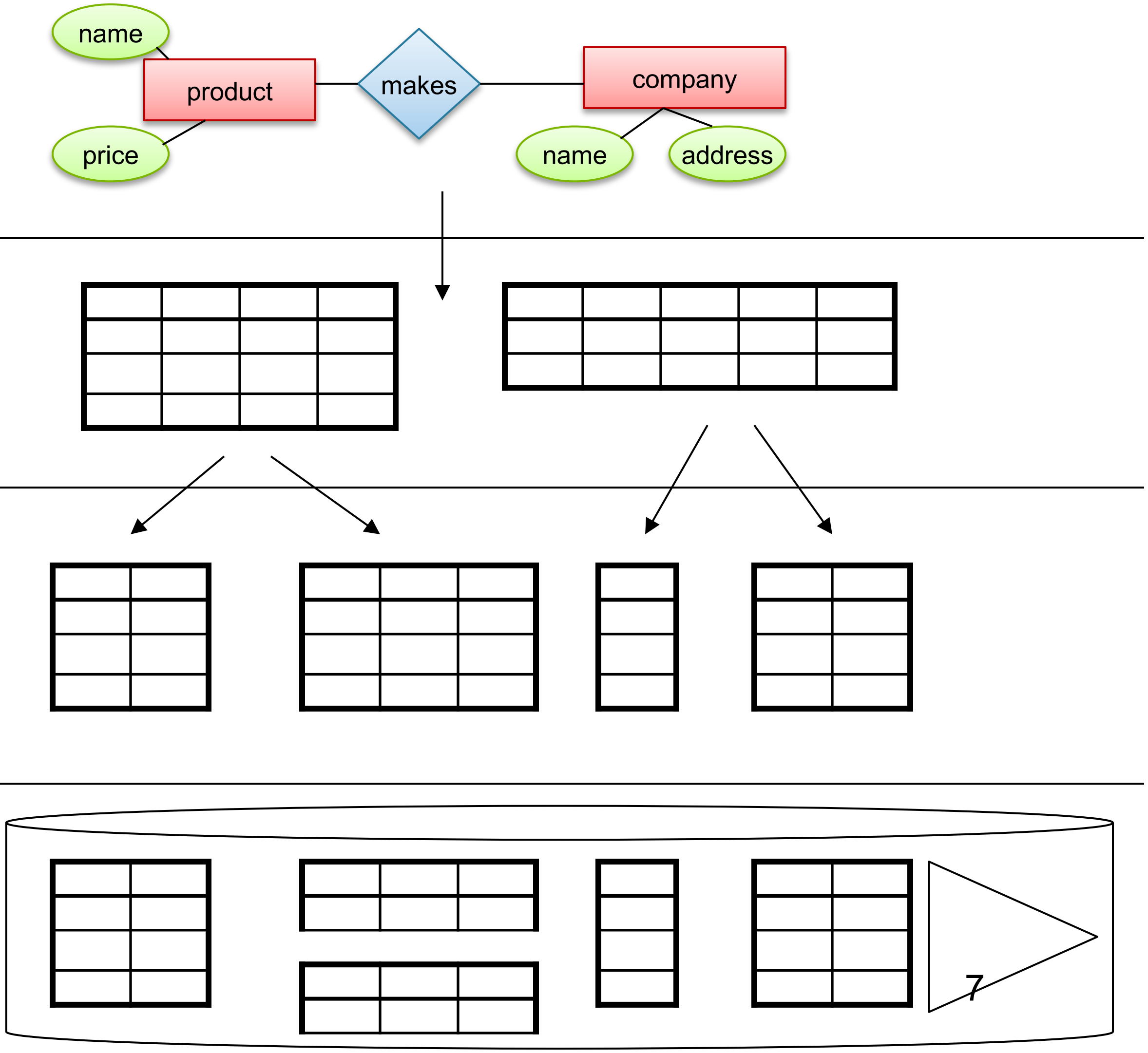
Relational Model:
Tables + constraints
And also functional dep.

Normalization:
Eliminates anomalies

Conceptual Schema

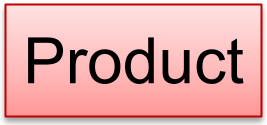
Physical storage details

Physical Schema

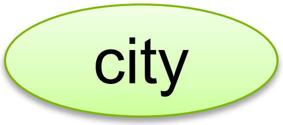


Entity / Relationship Diagrams

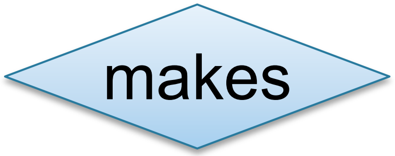
- Entity set = a class
  - An entity = an object

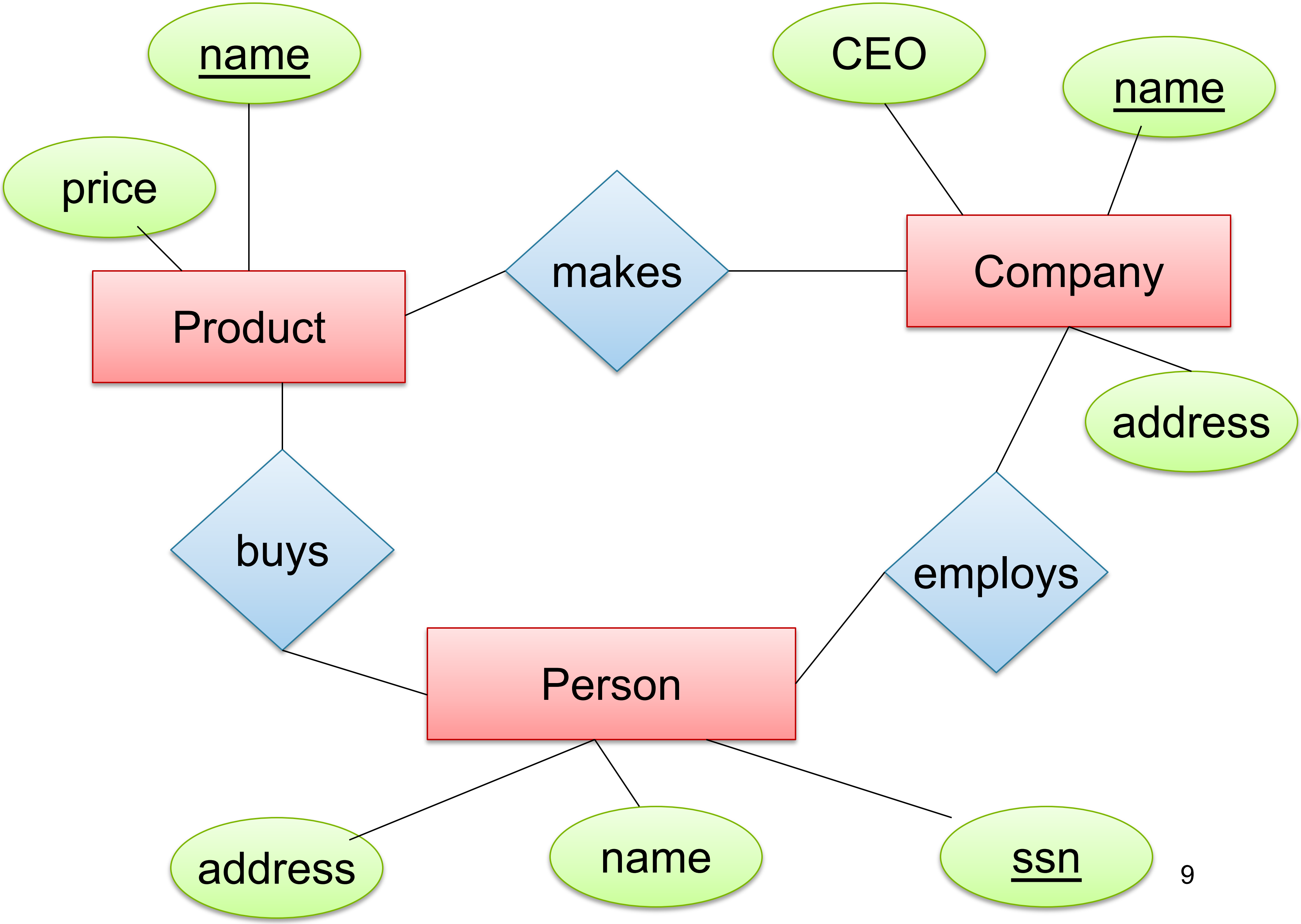

Product

- Attribute


city

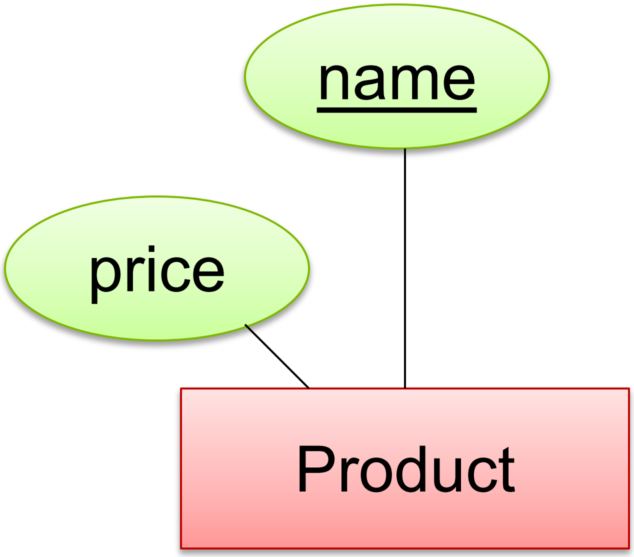
- Relationship


makes


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

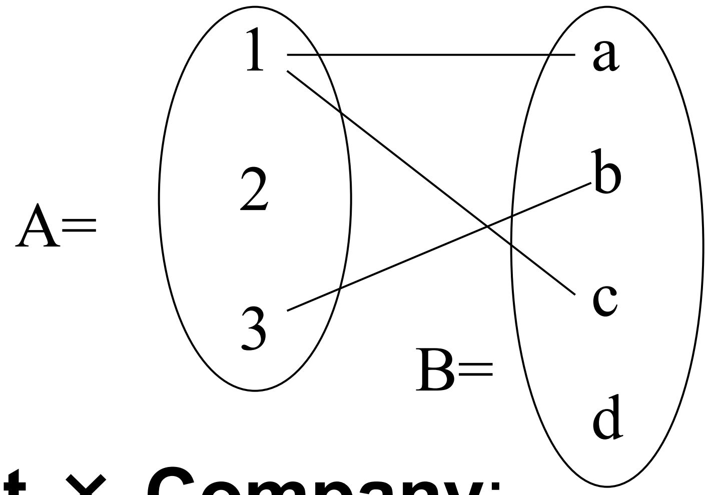


What is a Relation ?

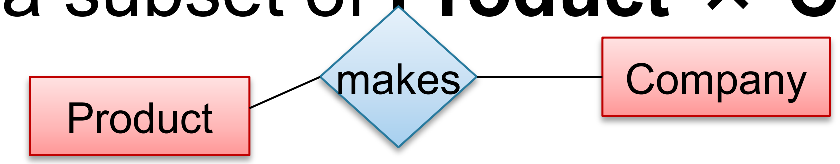
- A mathematical definition:
  - if A, B are sets, then a relation R is a subset of A × B
- A={1,2,3}, B={a,b,c,d},

  A × B = {(1,a),(1,b), . . ., (3,d)}

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

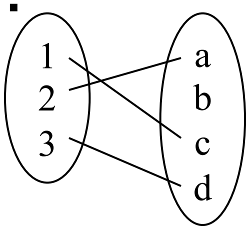


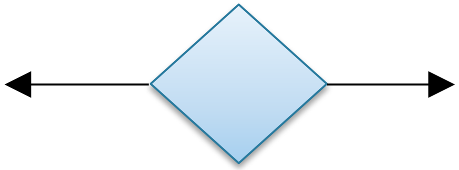
- **makes** is a subset of **Product × Company**:



Multiplicity of E/R Relations

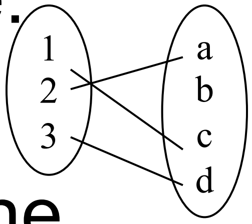
- one-one:

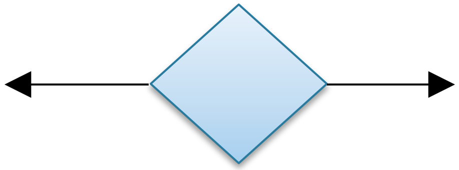




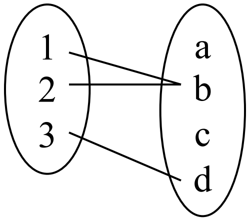
Multiplicity of E/R Relations

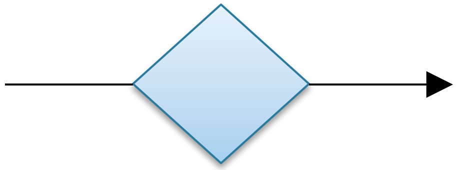
- one-one:





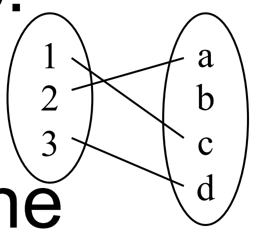
- many-one

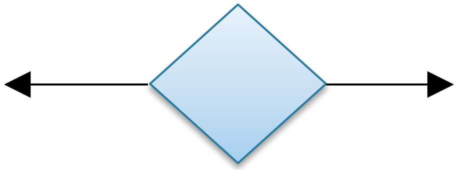




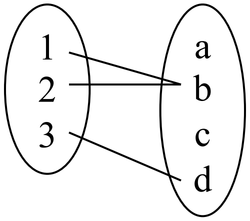
Multiplicity of E/R Relations

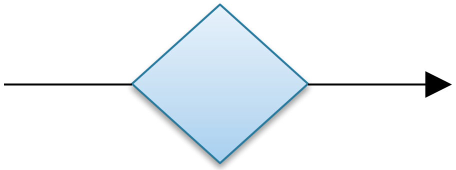
- one-one:



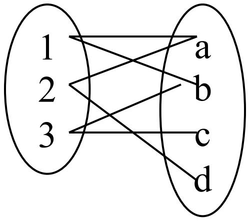


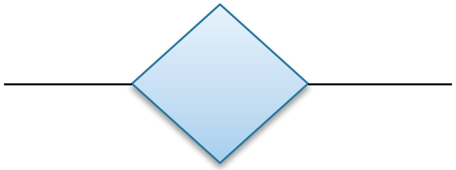
- many-one

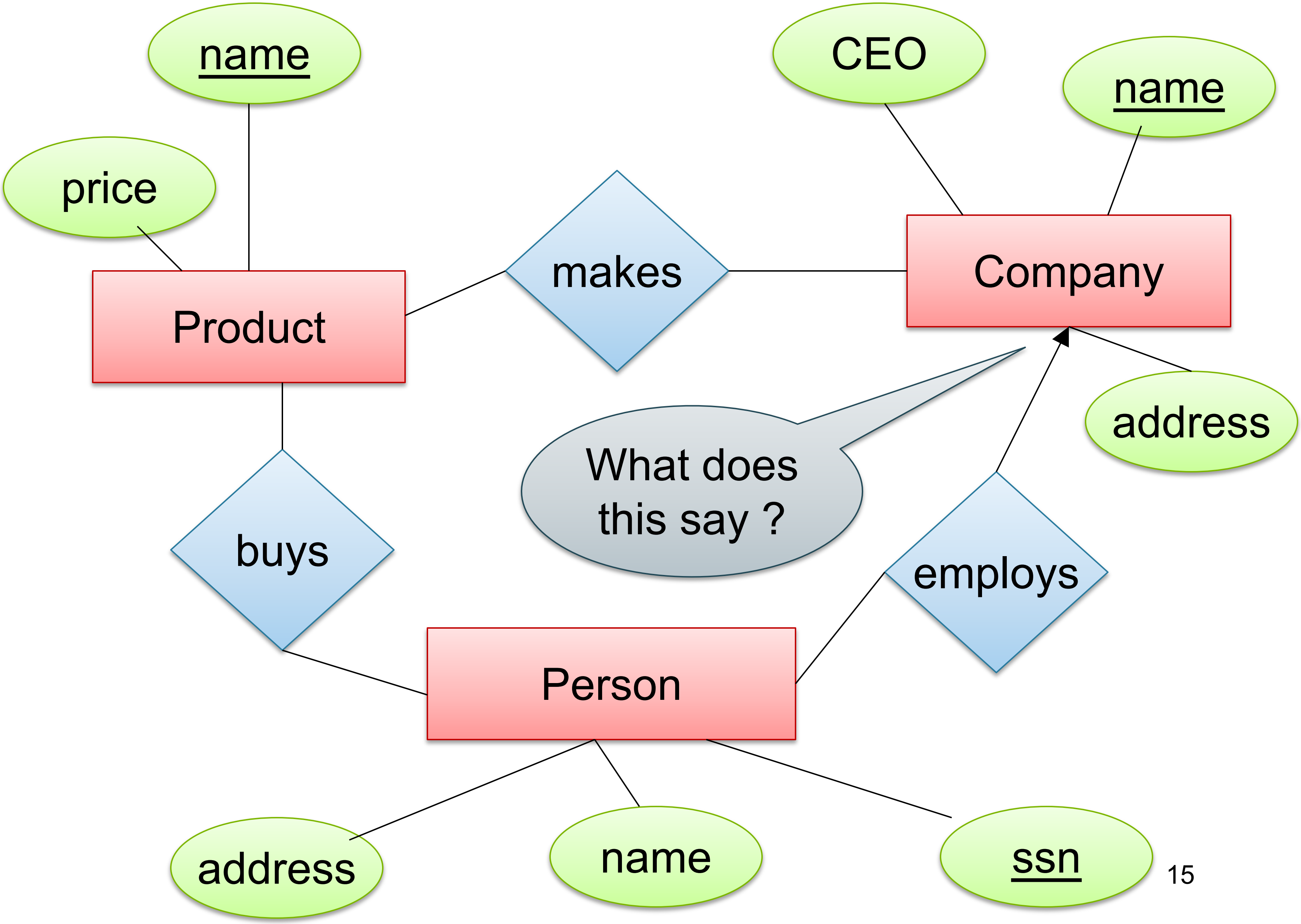




- many-many






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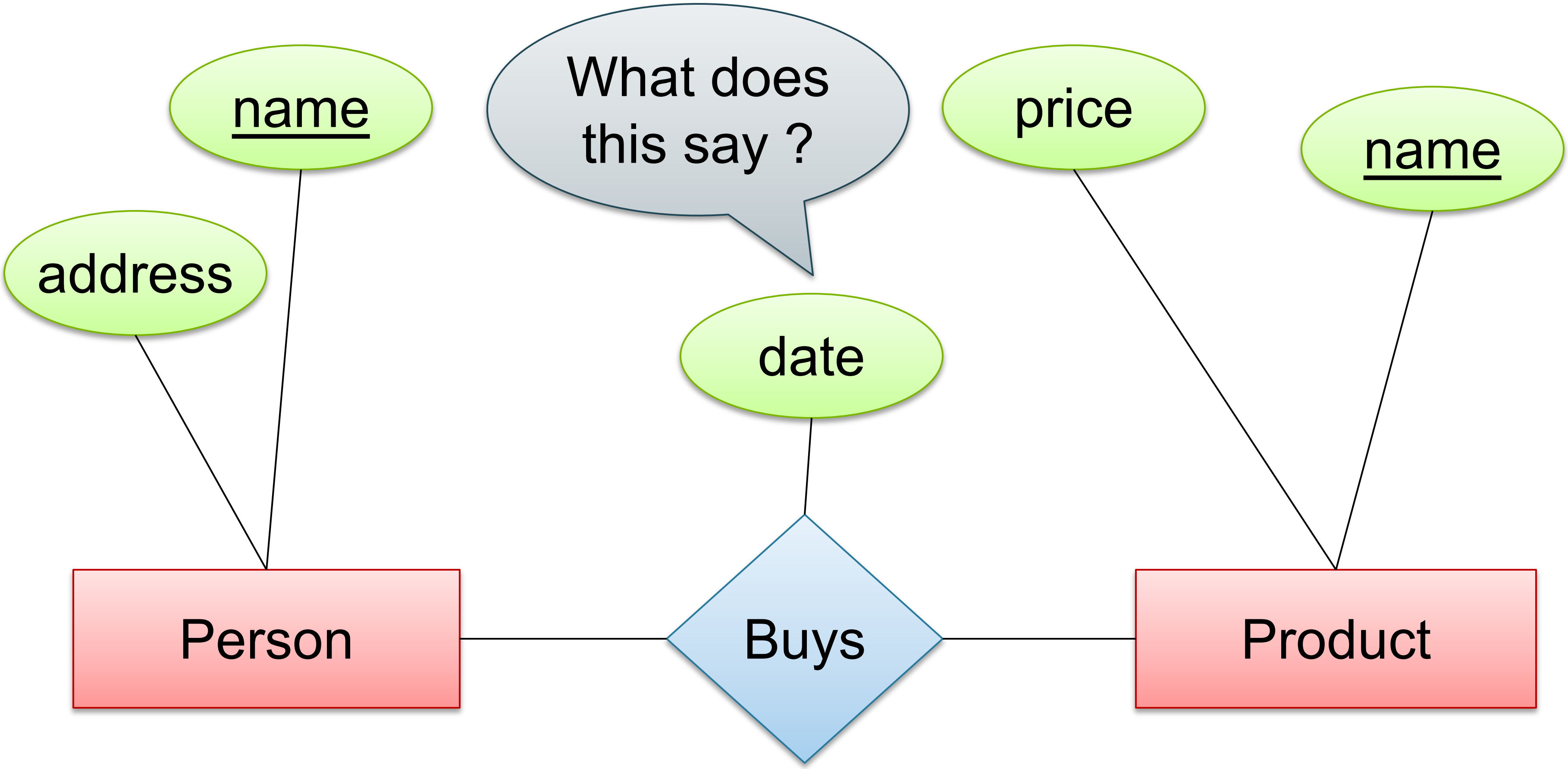
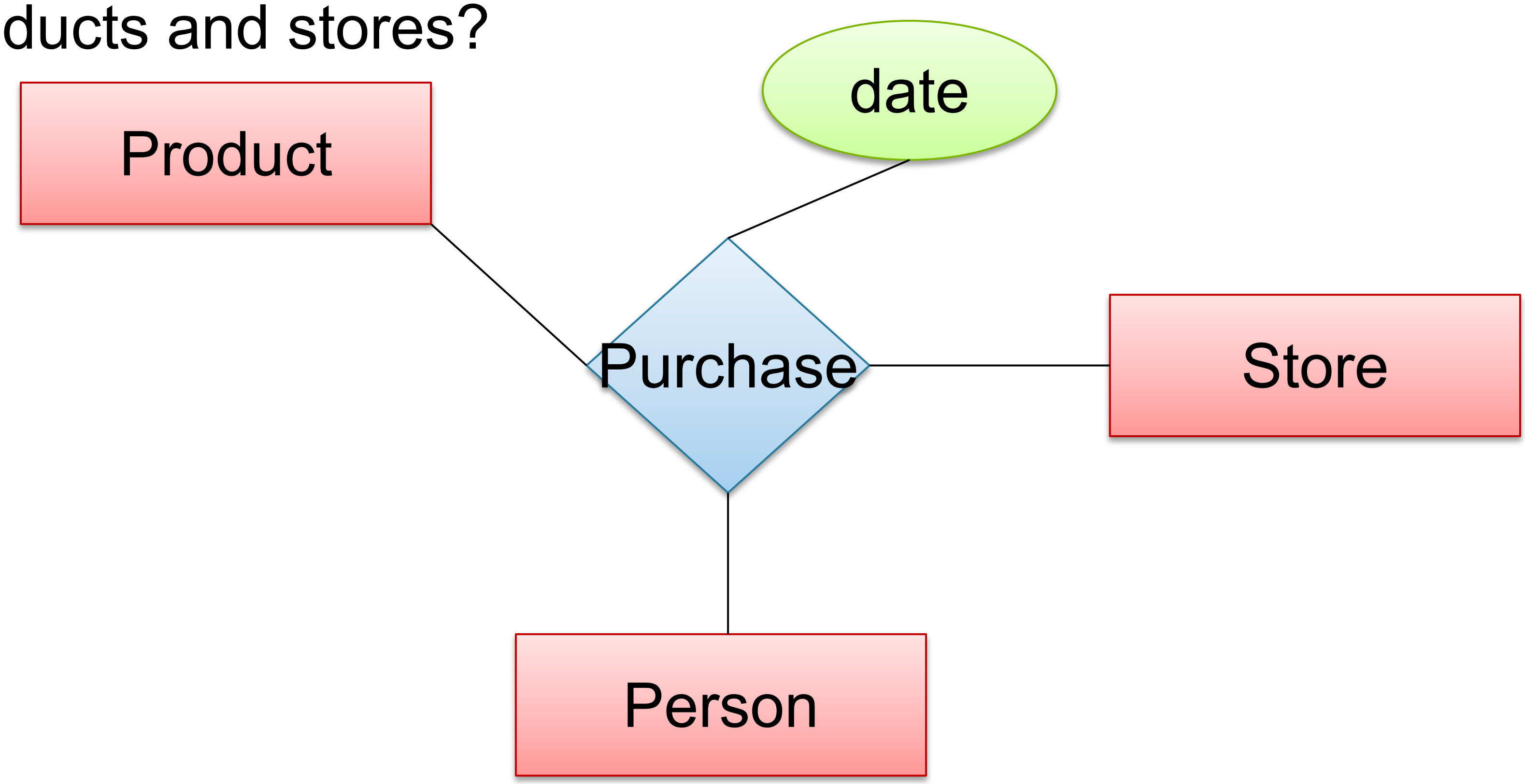
address
What does this say ?
buys
employs
Person
address
name
ssn

Attributes on Relationships



Multi-way Relationships

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

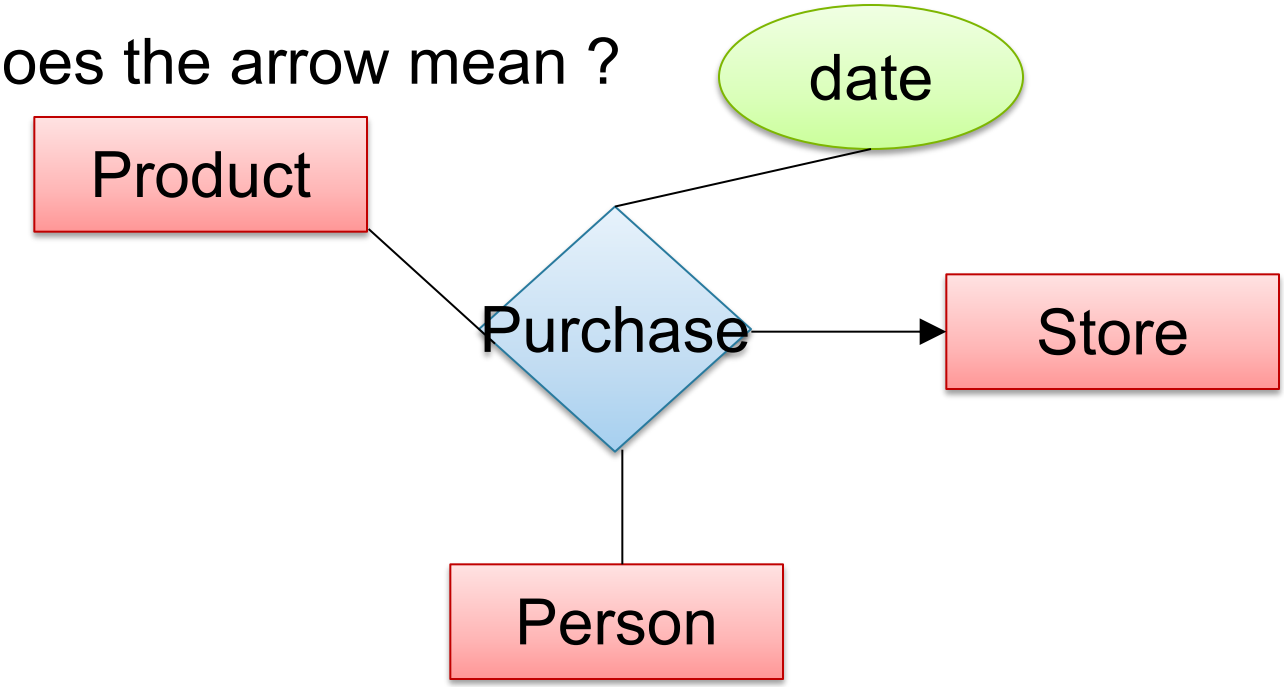


Can still model as a mathematical set (How?)

As a set of triples ⊆ Person × Product × Store

Arrows in Multiway Relationships

Q: What does the arrow mean ?

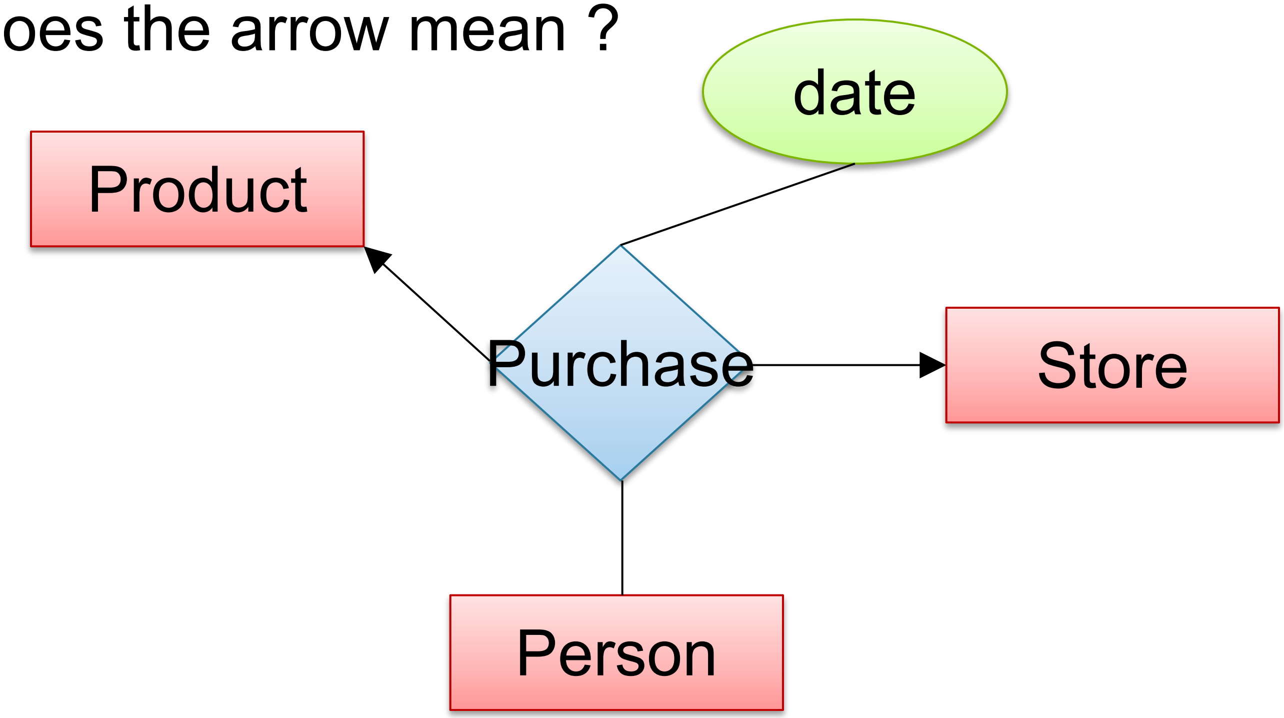


A: Any person buys a given product from at most one store

[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]

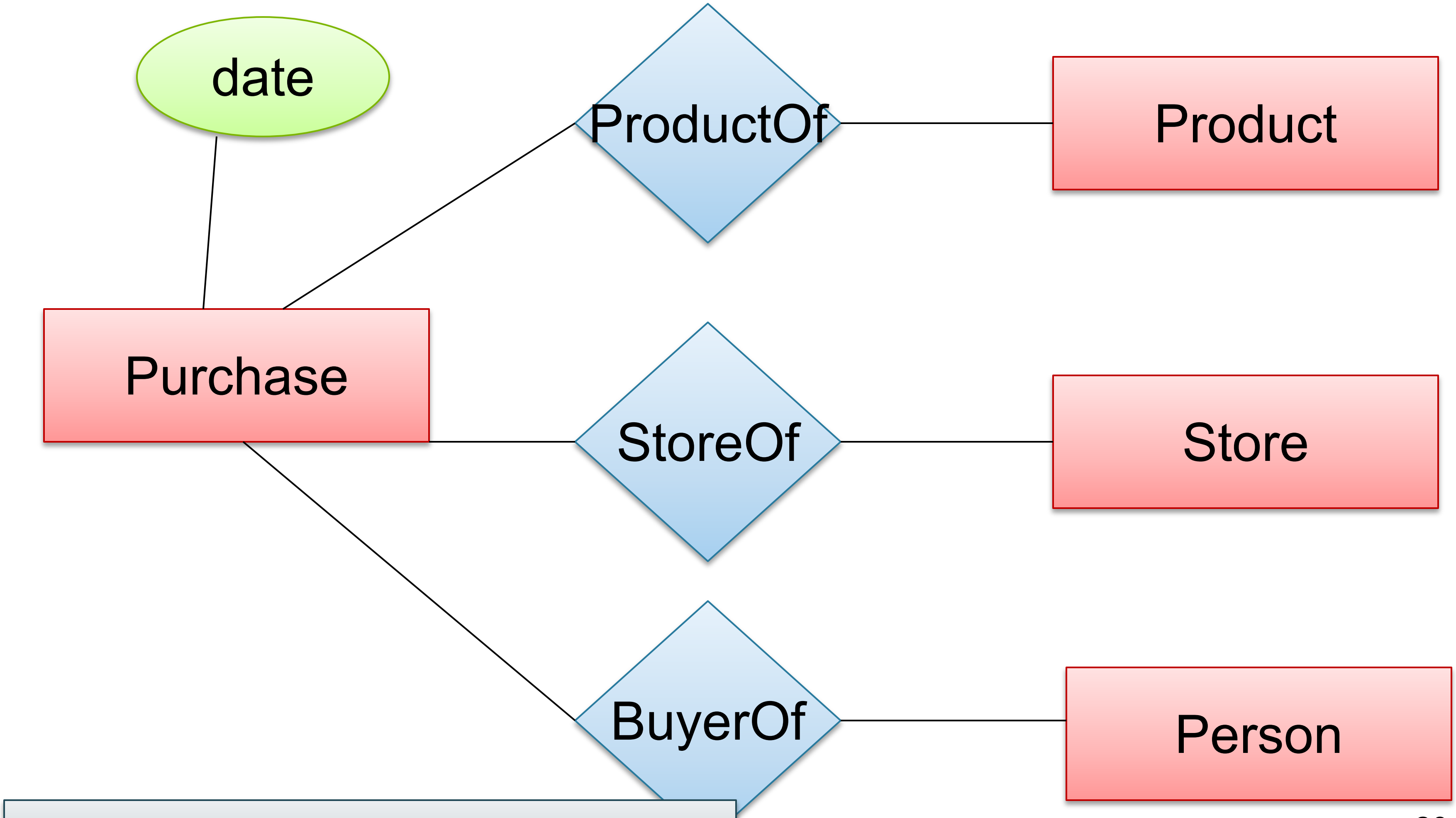
Arrows in Multiway Relationships

Q: What does the arrow mean ?



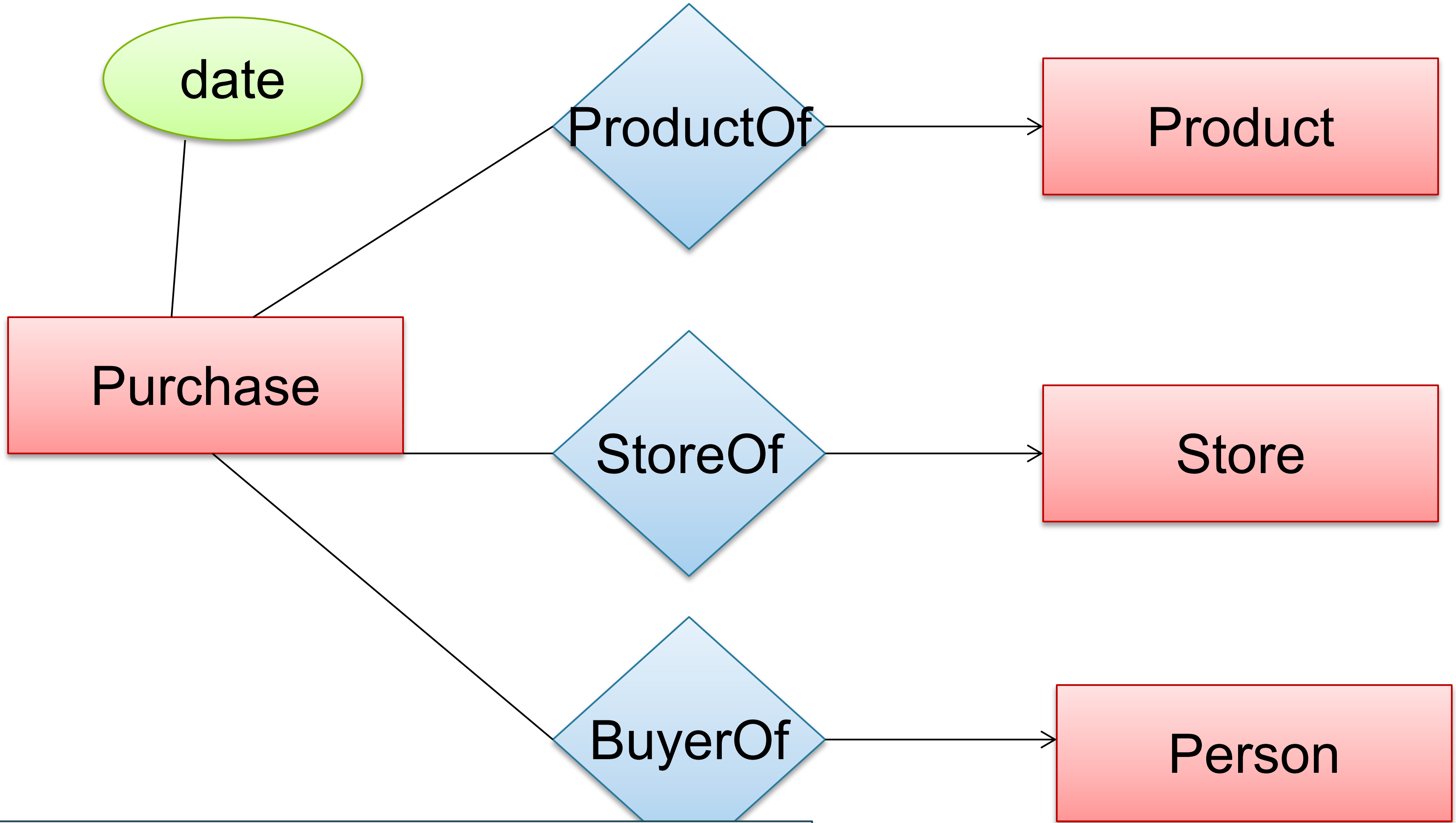
A: Any person buys a given product from at most one store AND every store sells to every person at most one product

Converting Multi-way Relationships to Binary



Arrows go in which direction?

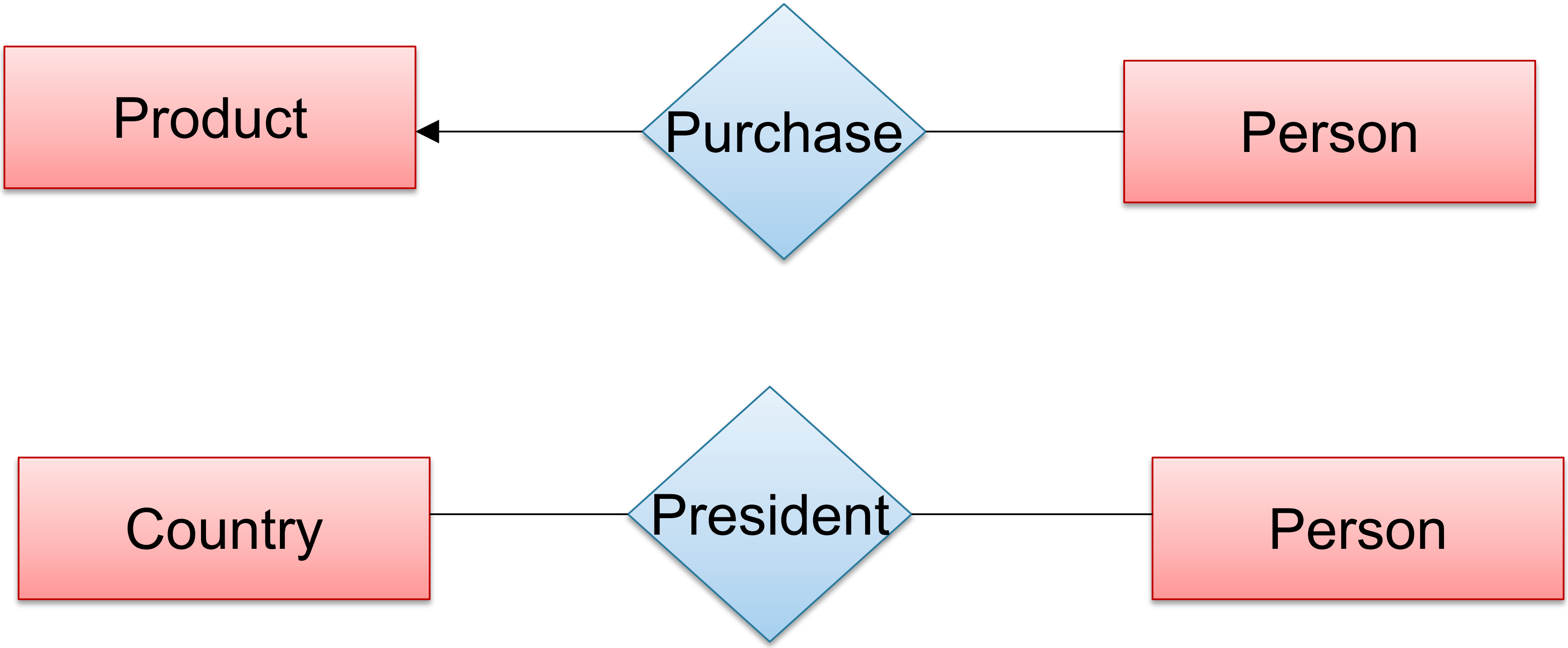
Converting Multi-way Relationships to Binary



Make sure you understand why!

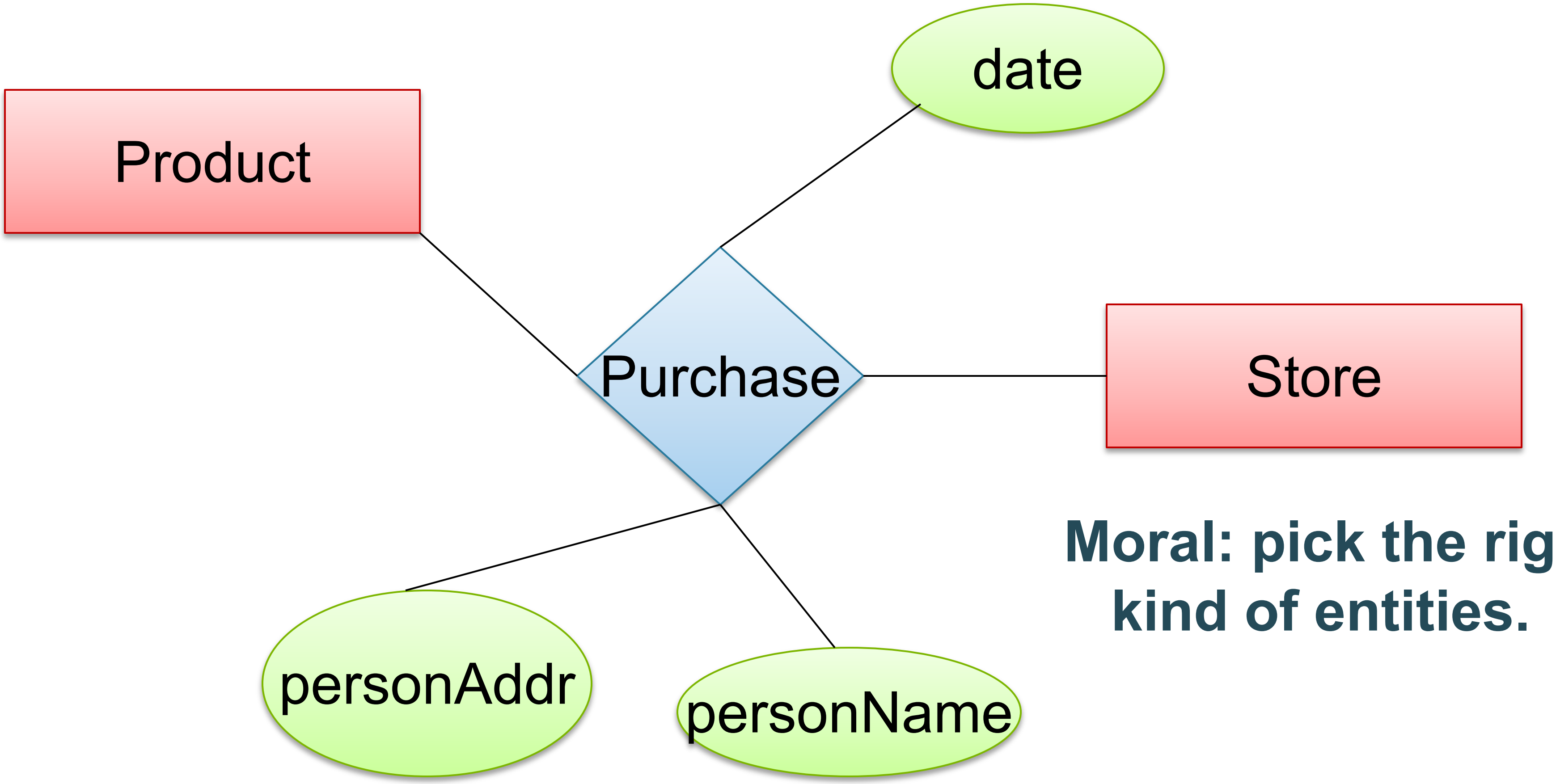
3. Design Principles

What's wrong?



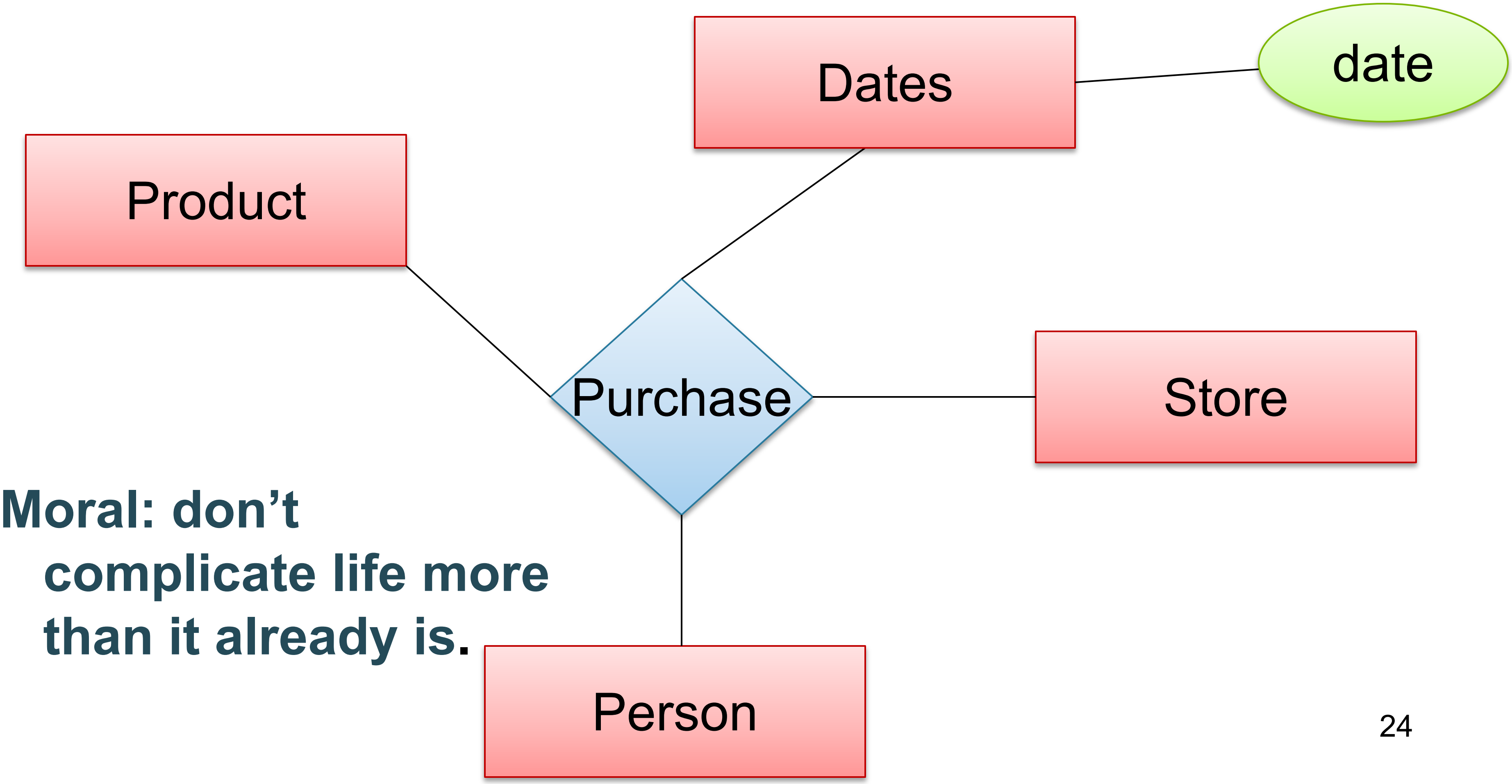
Moral: Be faithful to the specifications of the application!

Design Principles: What's Wrong?



Moral: pick the right kind of entities.

Design Principles: What's Wrong?

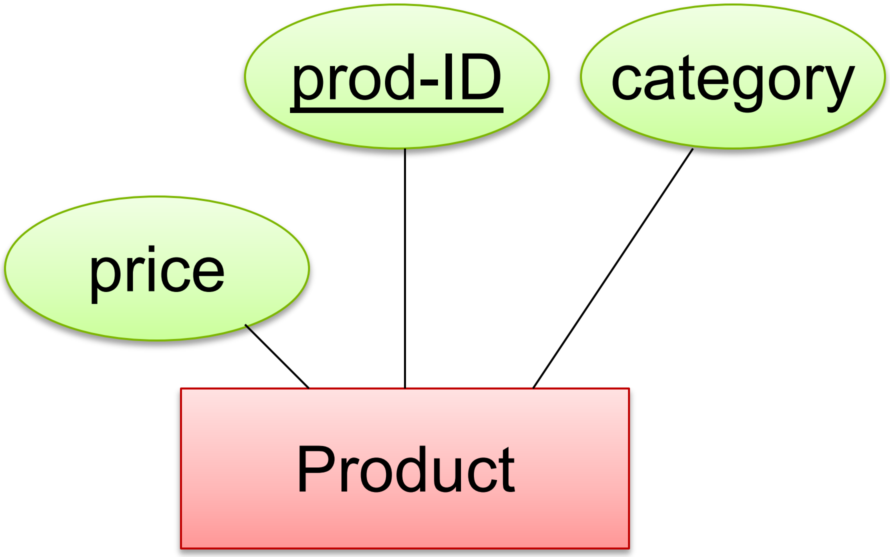


Moral: don't complicate life more than it already is.

From E/R Diagrams to Relational Schema

- Entity set → relation
- Relationship → relation

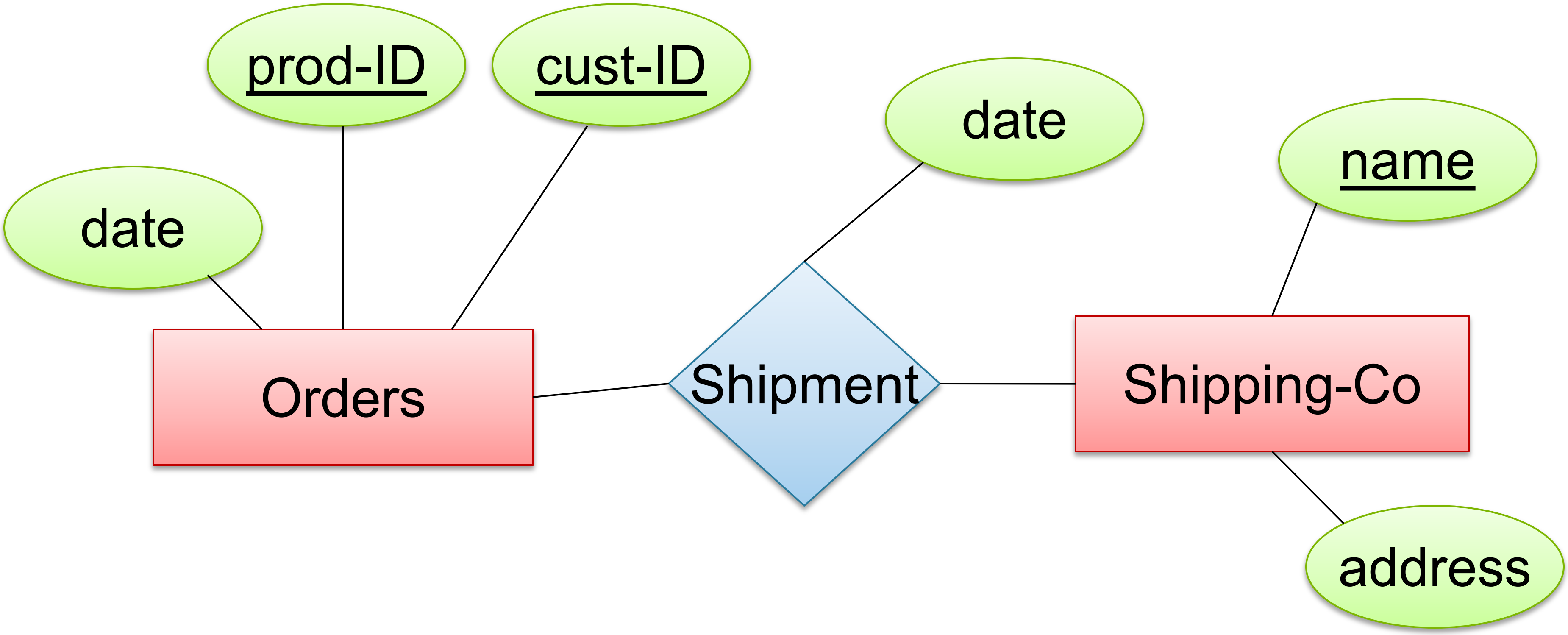
Entity Set to Relation



Product(prod-ID, category, price)

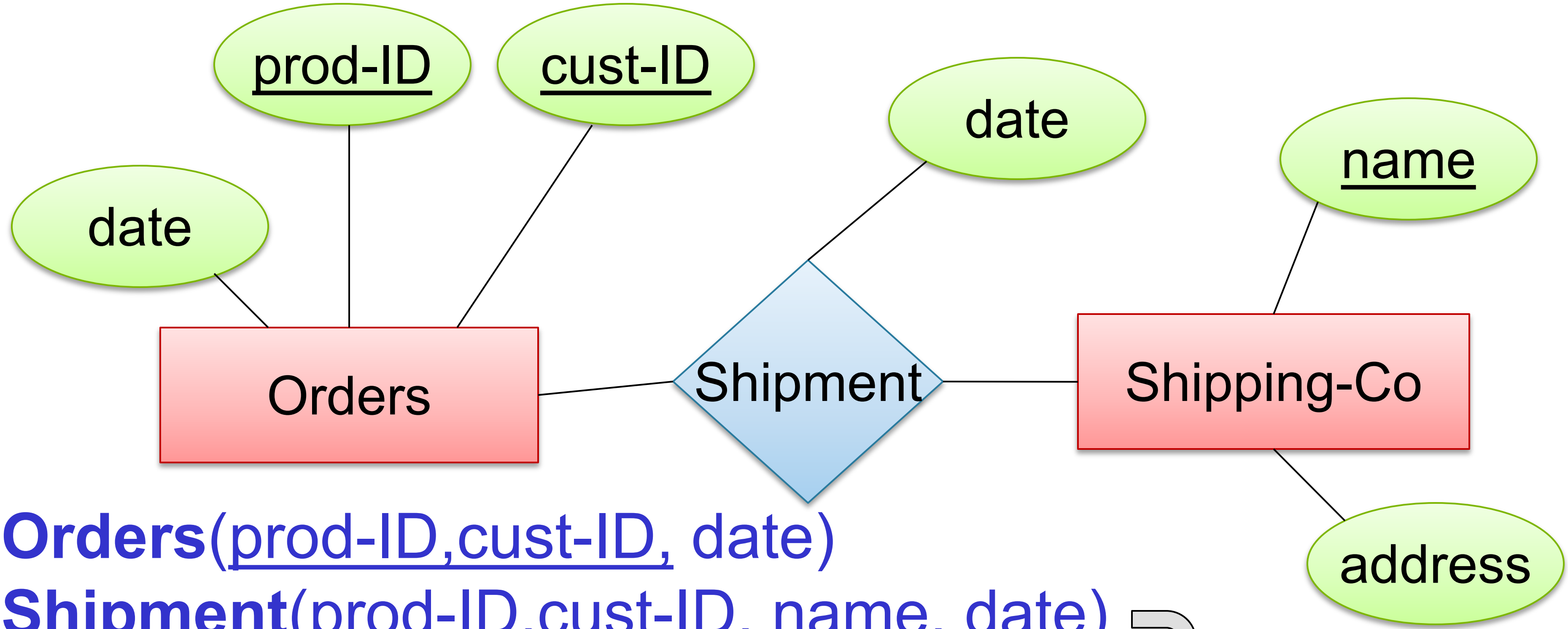
prod-ID	category	price
Gizmo55	Camera	99.99
Pokemn19	Toy	29.99

N-N Relationships to Relations



Represent this in relations

N-N Relationships to Relations



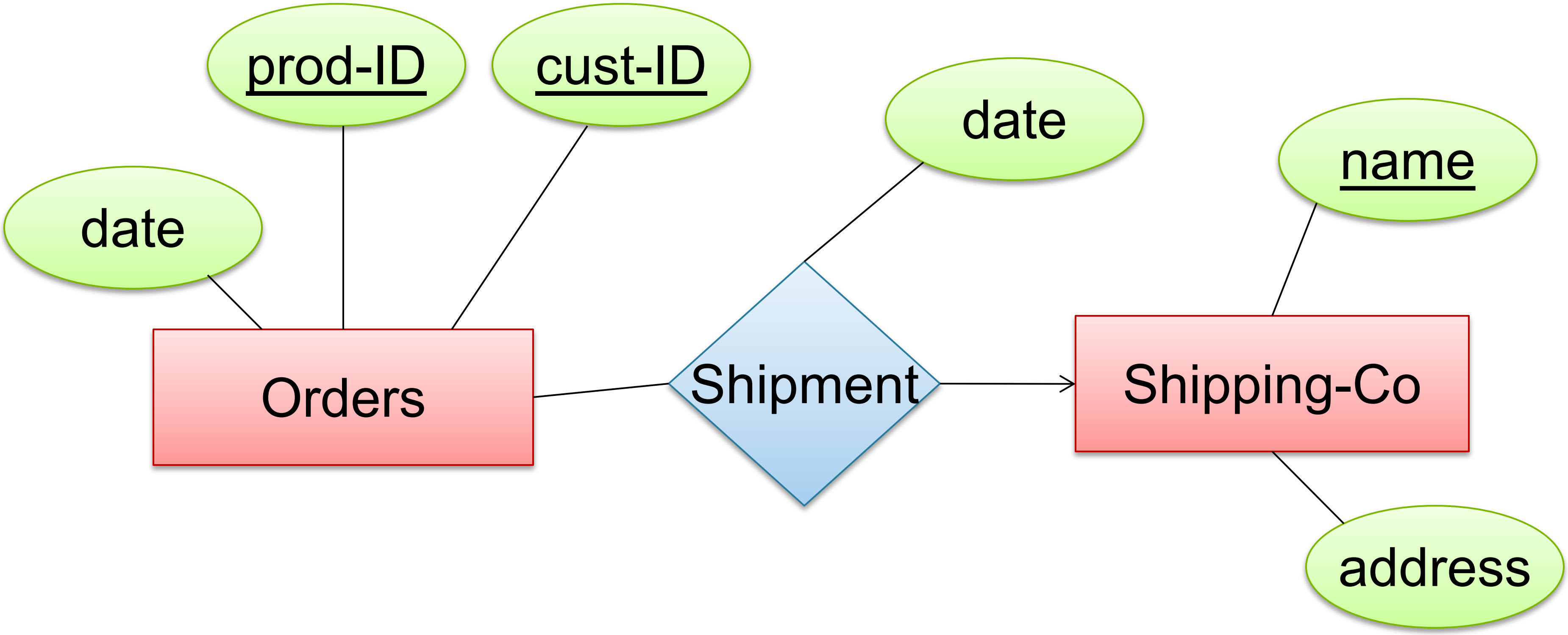
Orders(prod-ID,cust-ID, date)

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

Shipping-Co(name, address)

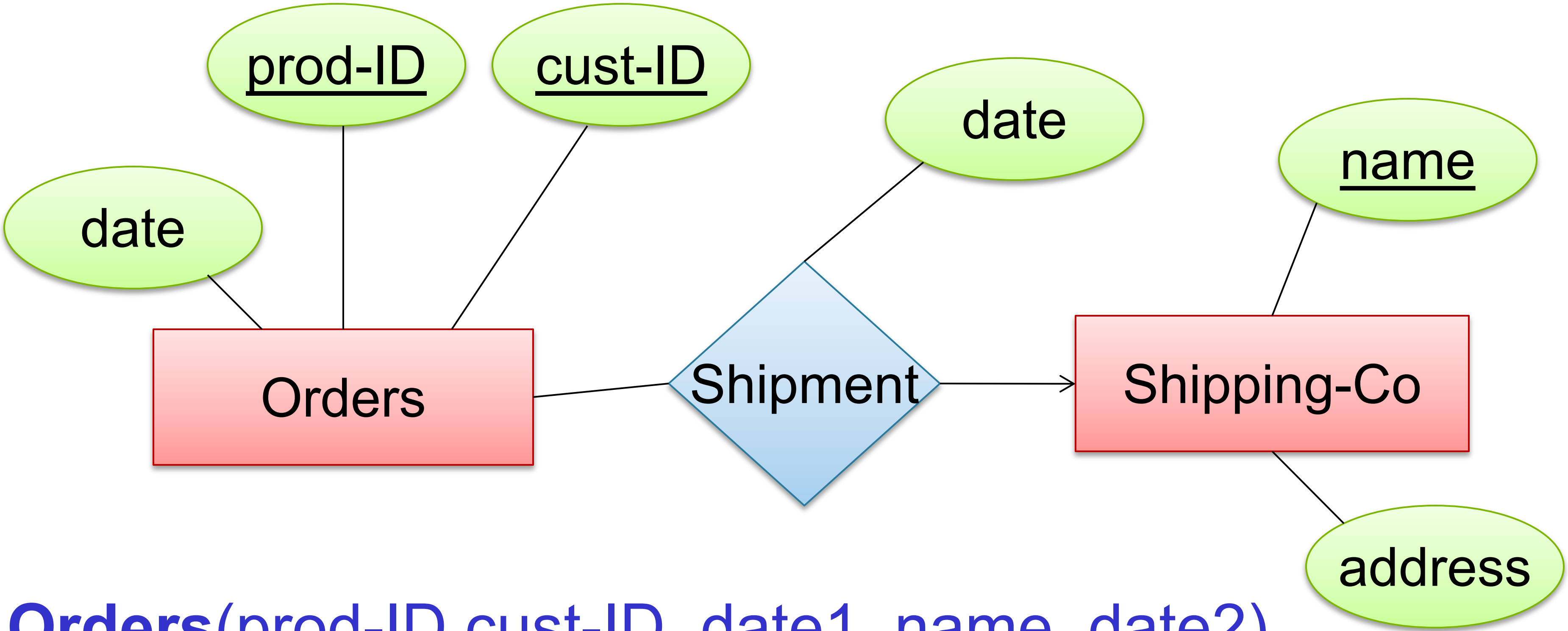
prod-ID	cust-ID	name	date
Gizmo55	Joe12	UPS	4/10/2011
Gizmo55	Joe12	FEDEX	4/9/2011

N-1 Relationships to Relations



Represent this in relations

N-1 Relationships to Relations



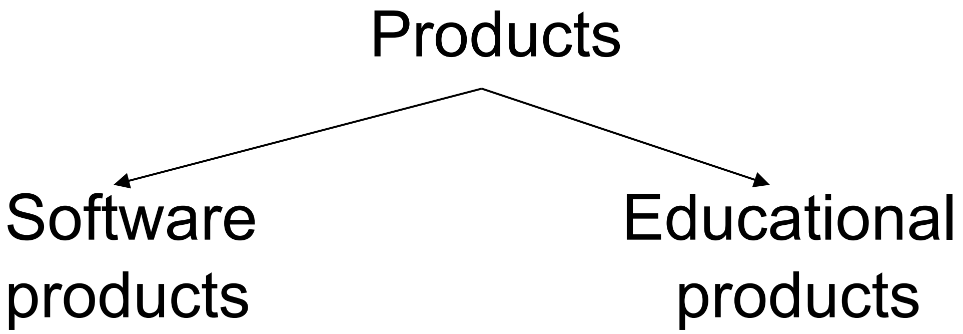
Orders(prod-ID,cust-ID, date1, name, date2)
Shipping-Co(name, address)

Remember: no separate relations for many-one relationship

Modeling Subclasses

Product

Name	Price	Category	Platforms	Age-group
Gizmo	99	gadget	unix	NULL
Camera	49	photo	NULL	NULL
Toy	39	gadget	NULL	infant



Products

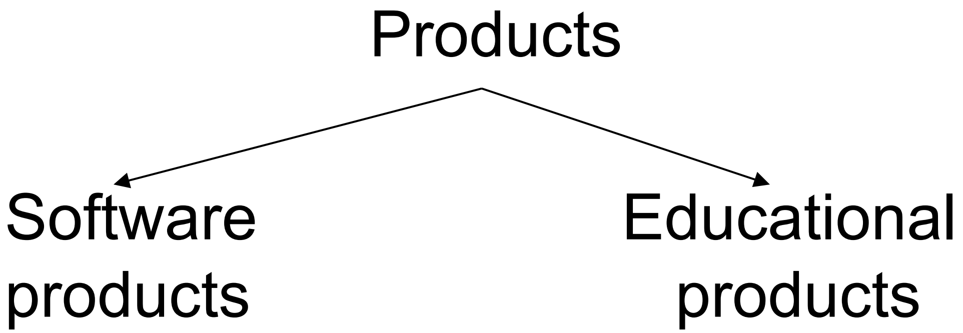
Software products

Educational products

Modeling Subclasses

Product

Name	Price	Category	Platforms	Age-group
Gizmo	99	gadget	unix	NULL
Camera	49	photo	NULL	NULL
Toy	39	gadget	NULL	infant



Products

Software products

Educational products

Modeling Subclasses

Product

Name	Price	Category
Camera	49	photo

Software Product

Name	Price	Category	Platforms
Gizmo	99	gadget	unix

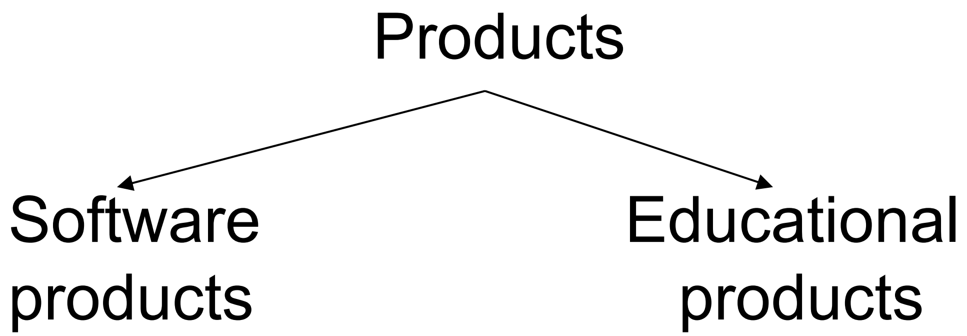
Educational Product

Name	Price	Category	Age-group
Toy	39	gadget	infant

Modeling Subclasses

Some objects in a class may be special

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



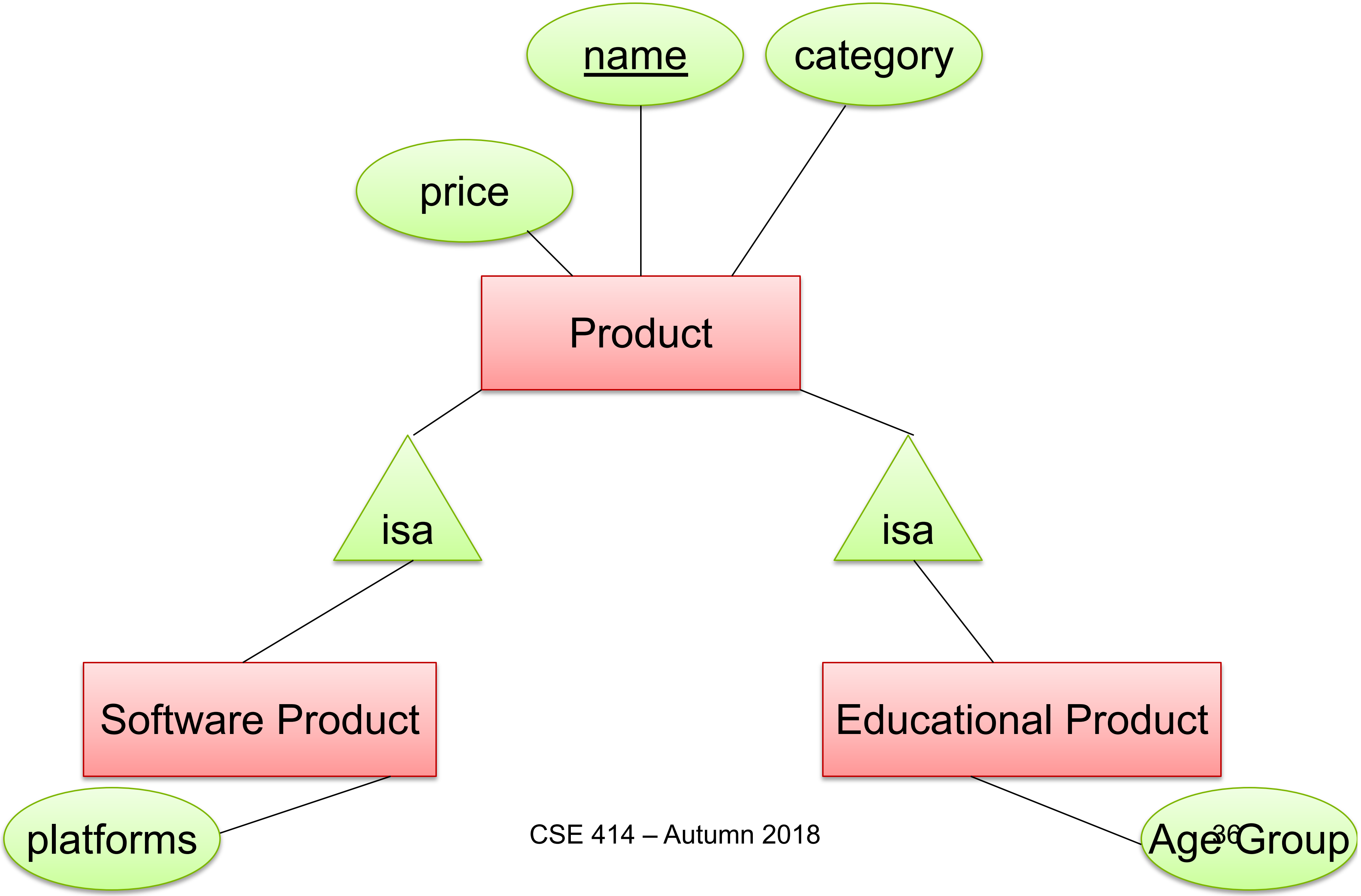
Products

Software products

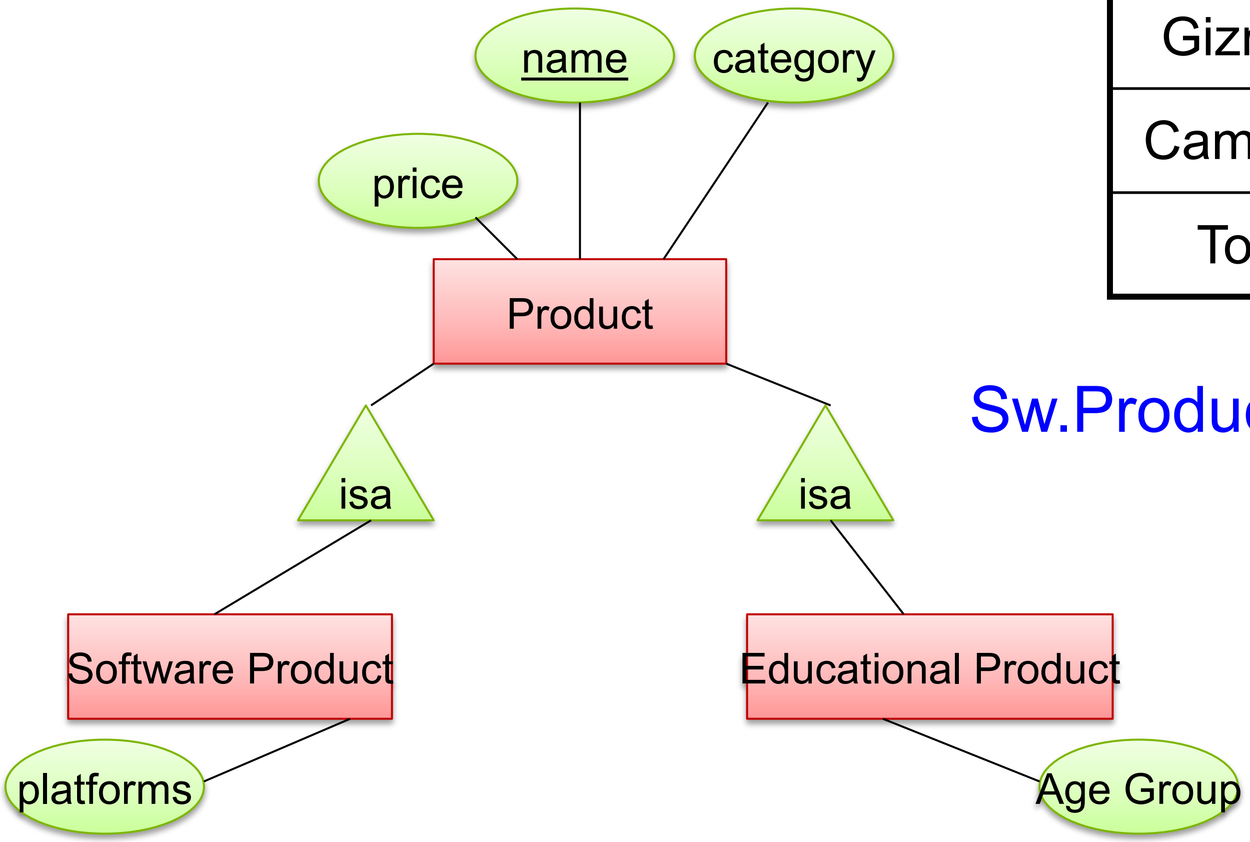
Educational products

So --- we define subclasses in E/R

Subclasses


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

Subclasses to Relations



Product

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

Sw.Product

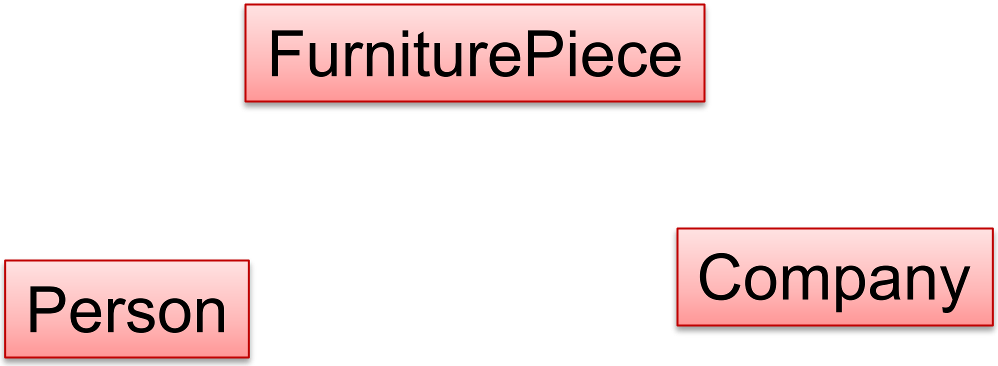
Name	platforms
Gizmo	unix

Ed.Product

Name	Age Group
Gizmo	toddler
Toy	retired

Other ways to convert are possible

Modeling Union Types with Subclasses



FurniturePiece

Person

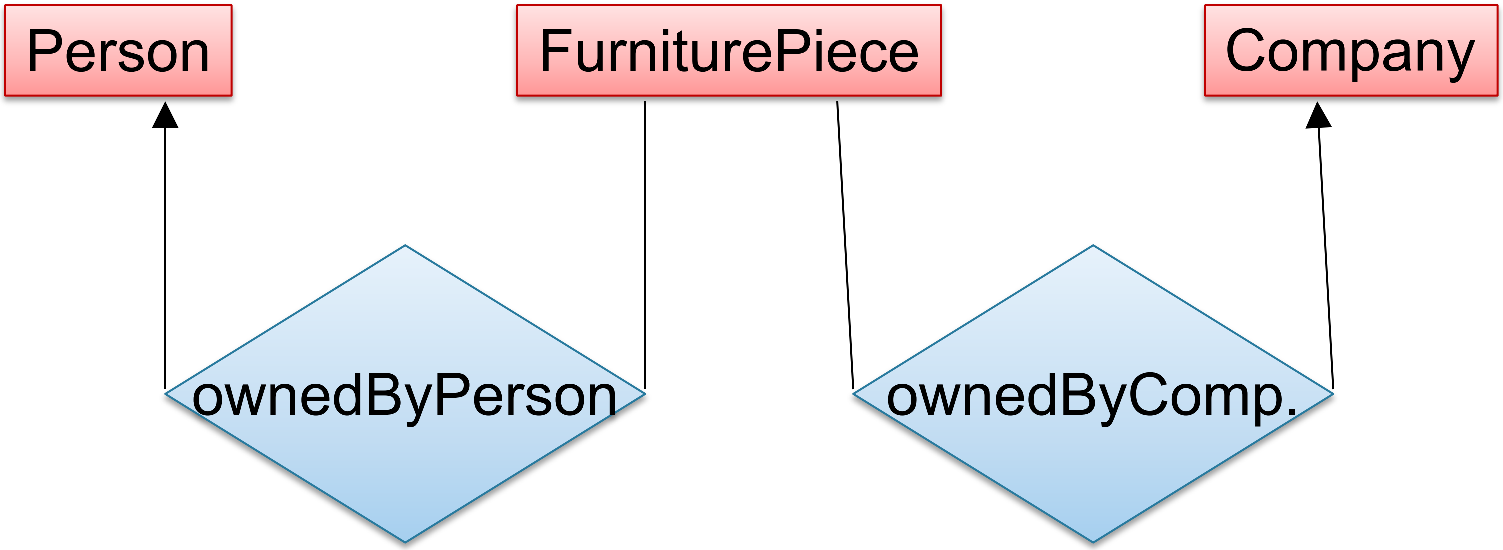
Company

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

Modeling Union Types with Subclasses

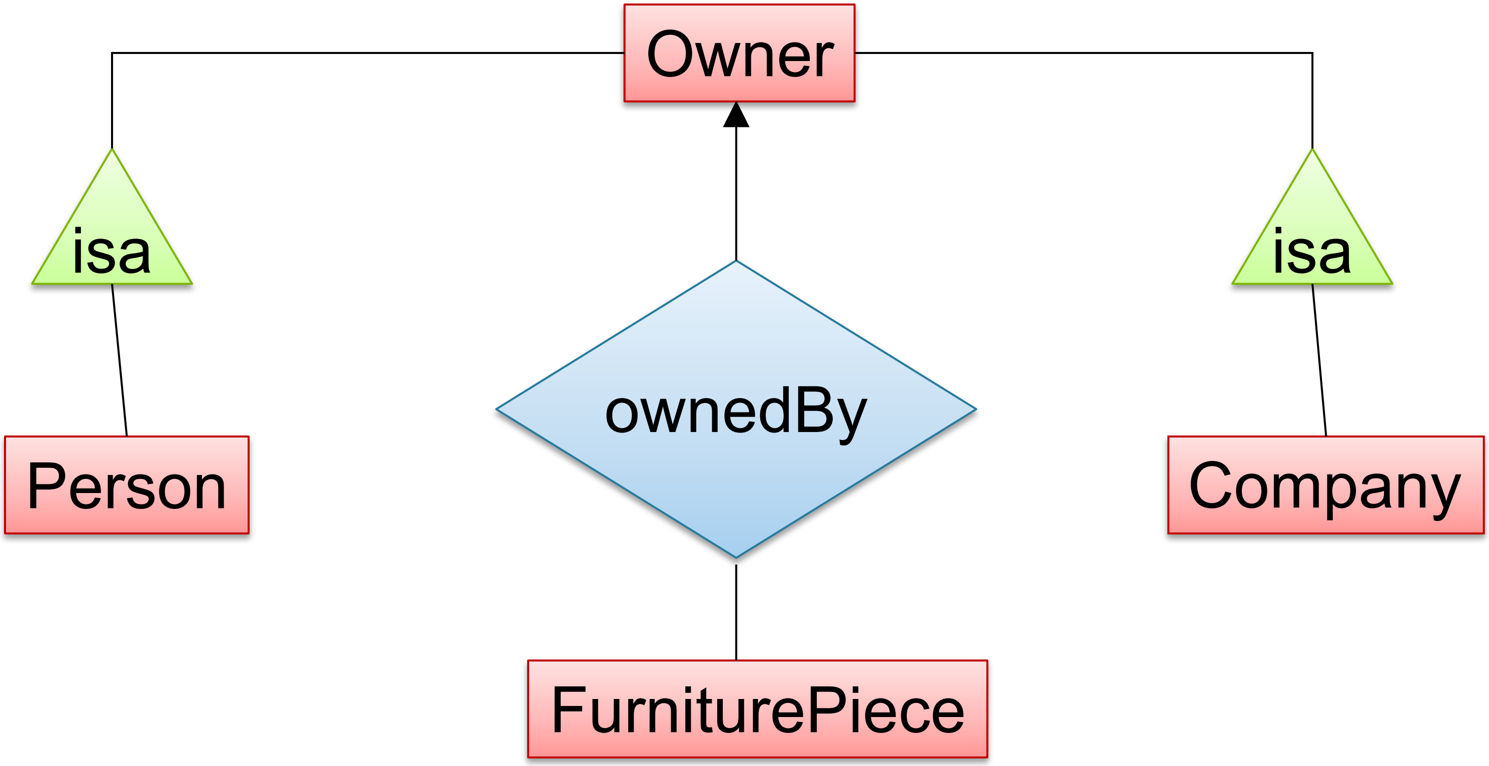
Say: each piece of furniture is owned either by a person or by a company

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



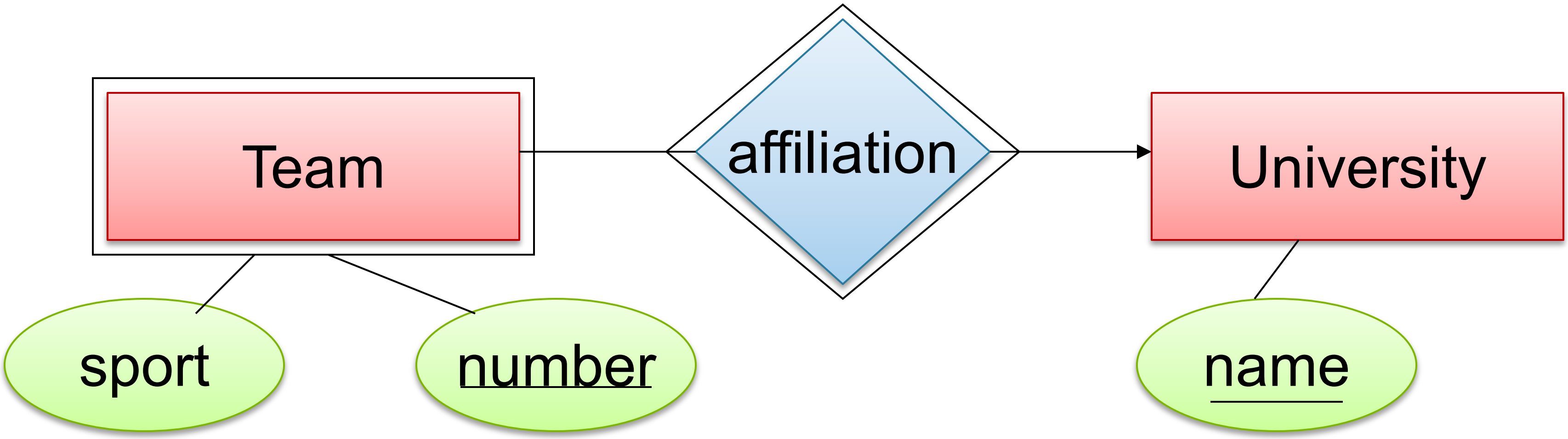
Modeling Union Types with Subclasses

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, number, universityName)
University(name)

Introduction to Data Management
CSE 344

Integrity Constraints

Integrity Constraints Motivation

An integrity constraint is a condition specified on a database schema that restricts the data that can be stored in an instance of the database.

- ICs help prevent entry of incorrect information
- How? DBMS enforces integrity constraints
  - Allows only legal database instances (i.e., those that satisfy all constraints) to exist
  - Ensures that all necessary checks are always performed and avoids duplicating the verification logic in each application

Constraints in E/R Diagrams

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

Keys: social security number uniquely identifies a person.

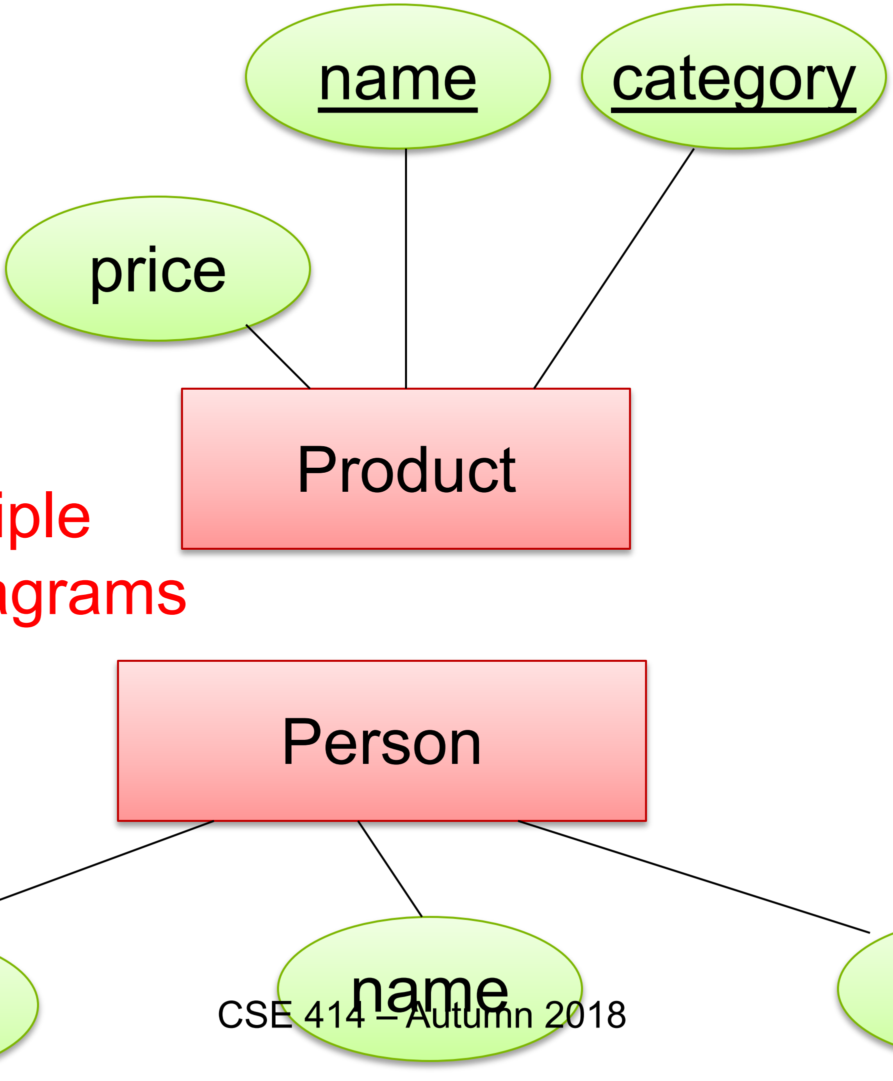
Single-value constraints: a person can have only one father.

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

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

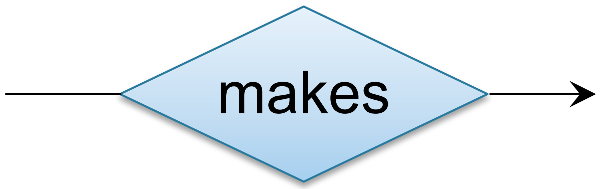
Keys in E/R Diagrams

Underline:

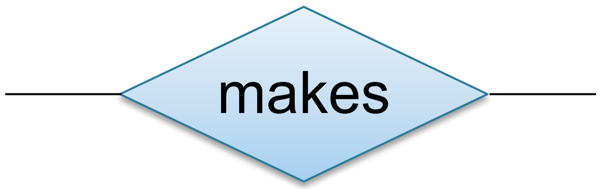


No formal way to specify multiple keys in E/R diagrams

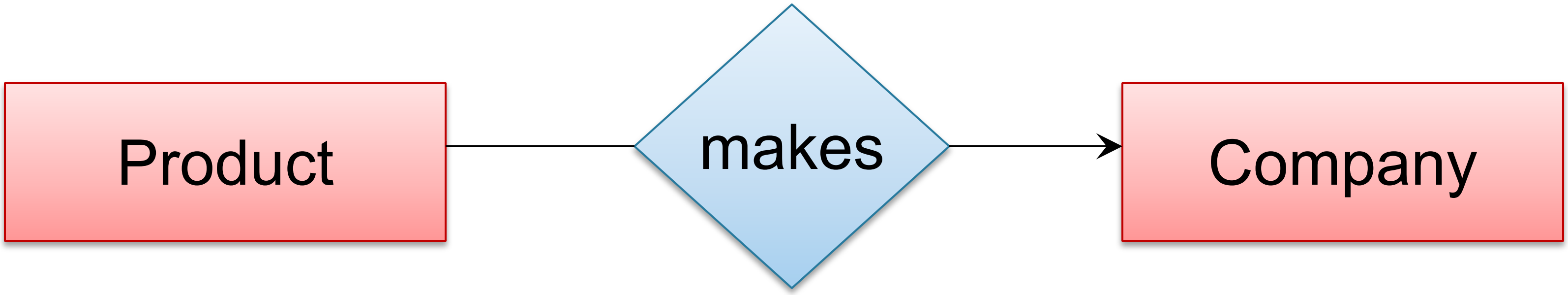
Single Value Constraints



vs.



Referential Integrity Constraints

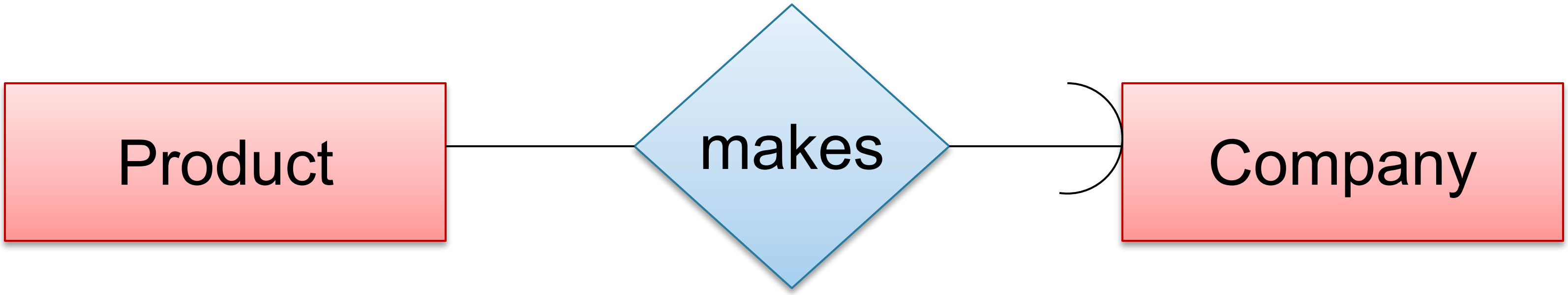


Product

makes

Company

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



Product

makes

Company

Each product made by ***exactly*** one company.