Introduction to Data Management
CSE 344

Lecture 17: E/R Diagrams and Constraints

Announcements

- HW5 due this Friday
  – Please note minor update to the instructions
- WQ6 due next Wednesday

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
- Reading: Sec. 4.1-4.6

Database Design Process

Conceptual Model:

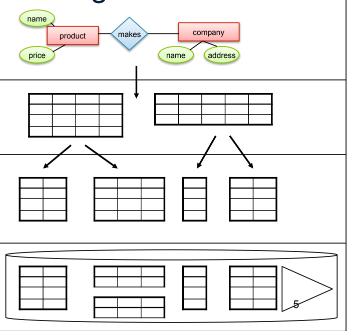
Relational Model:
Tables + constraints
And also functional dep.

Normalization:
Eliminates anomalies

Conceptual Schema

Physical storage details

Physical Schema



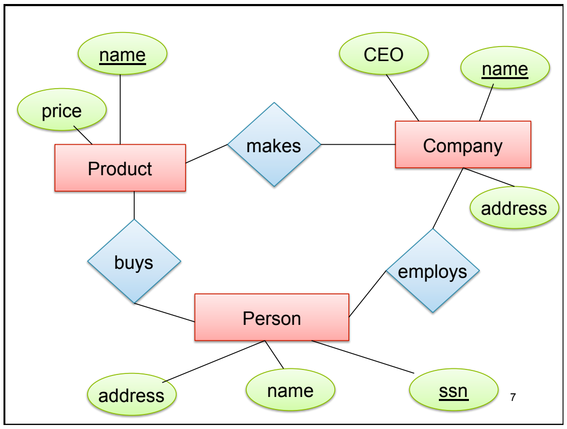
Entity / Relationship Diagrams

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

Product

city

makes



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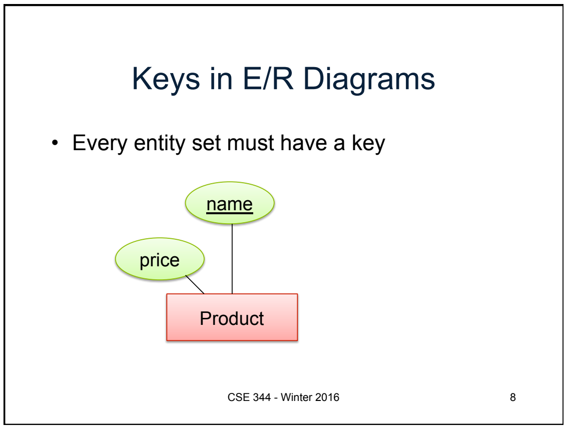
Keys in E/R Diagrams

- Every entity set must have a key

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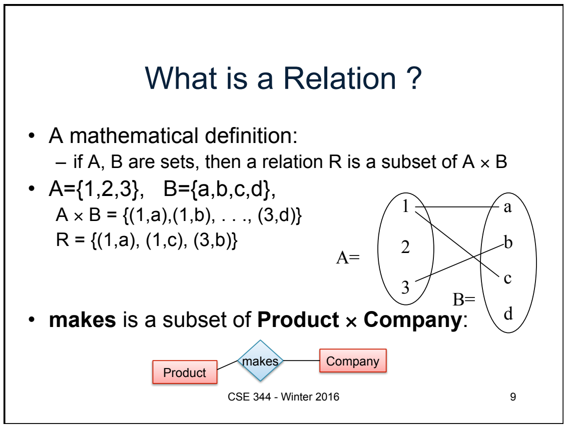
What is a Relation ?

- 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**:

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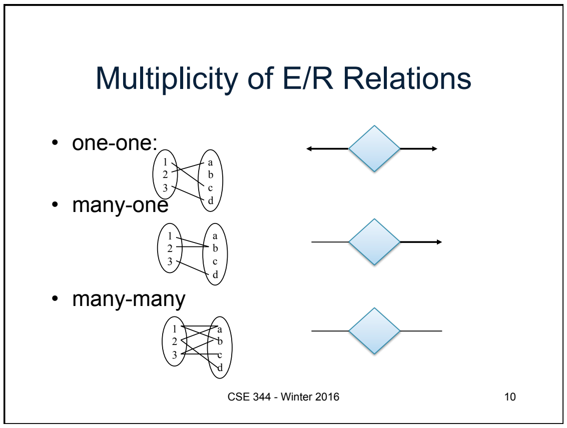
Multiplicity of E/R Relations

- one-one:
- many-one
- many-many

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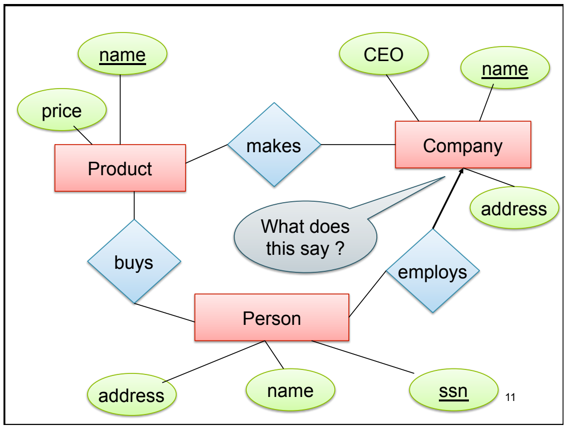

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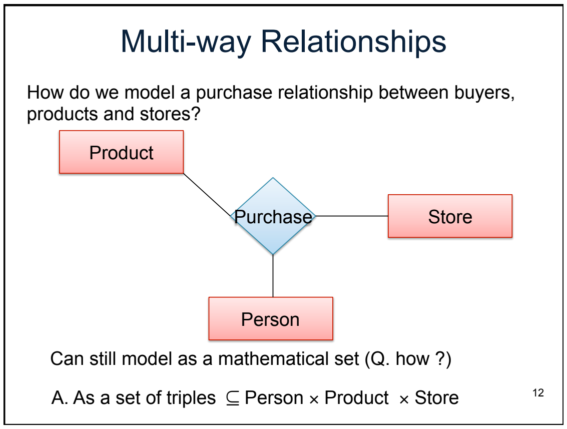
Multi-way Relationships

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 ⊆ Person × Product × Store

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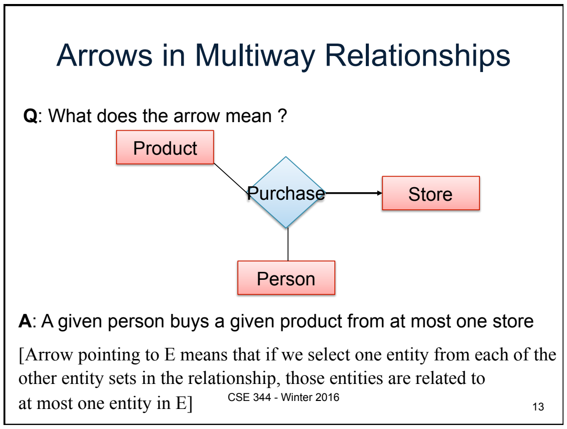


Arrows in Multiway Relationships

Q: What does the arrow mean ?

Product

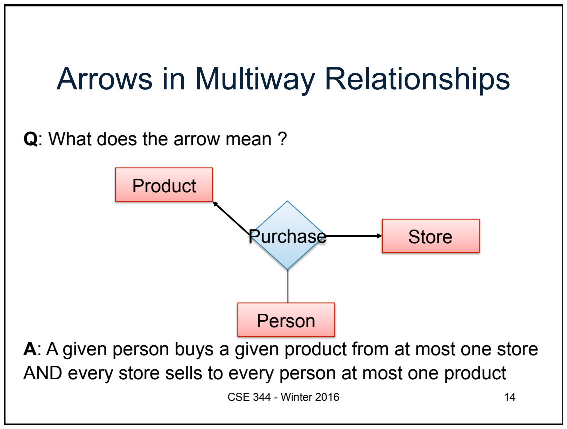
Purchase

Store

Person

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 ?

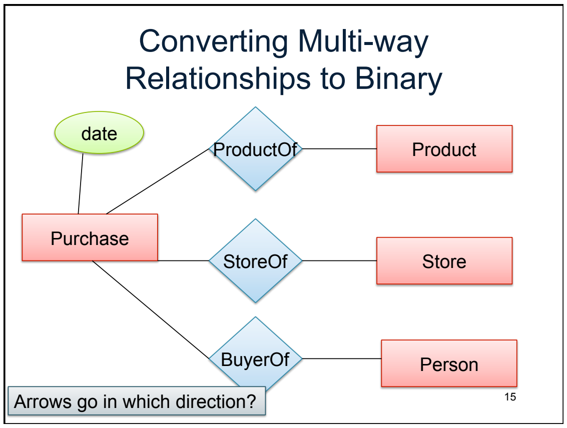
Product

Purchase

Store

Person

A: A given 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

date

ProductOf

Product

Purchase

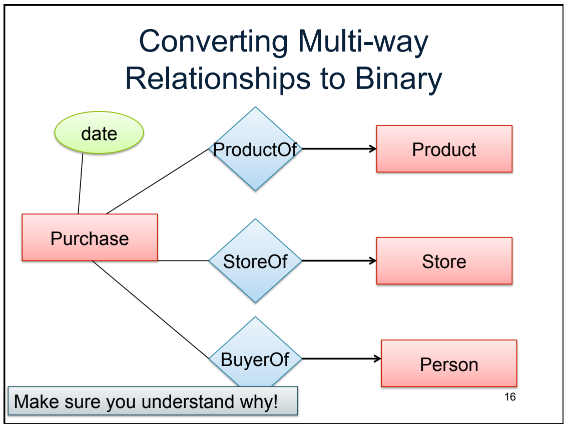
StoreOf

Store

BuyerOf

Person

Arrows go in which direction?



Converting Multi-way Relationships to Binary

date

ProductOf

Product

Purchase

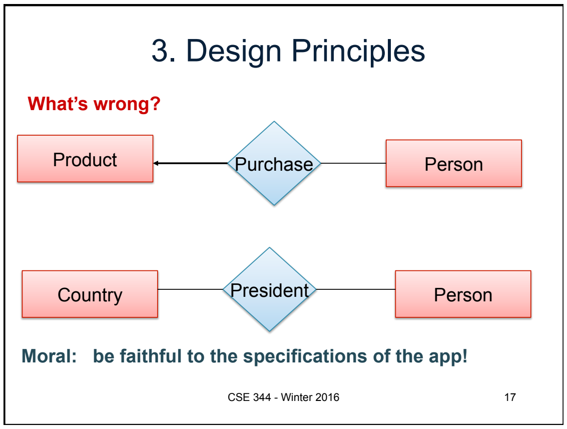
StoreOf

Store

BuyerOf

Person

Make sure you understand why!



3. Design Principles

What's wrong?

Product

Purchase

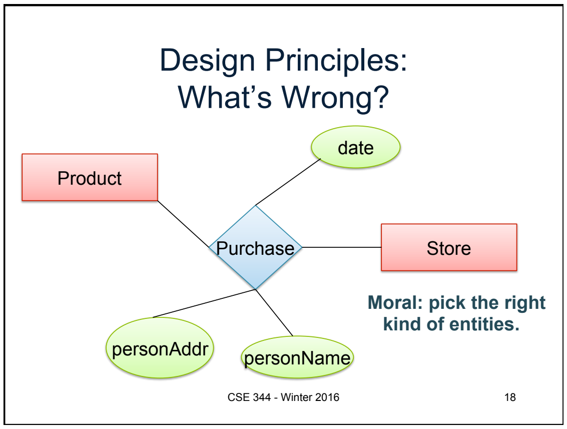
Person

Country

President

Person

Moral: be faithful to the specifications of the app!



Design Principles: What's Wrong?

date

Product

Purchase

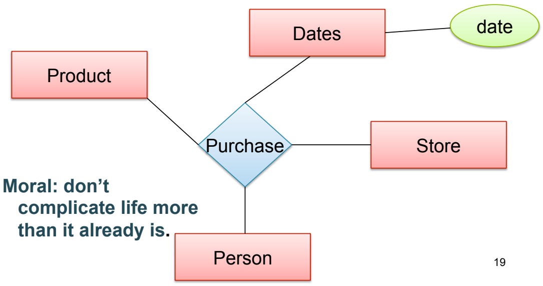
Store

personAddr

personName

Moral: pick the right kind of entities.

Design Principles: What's Wrong?

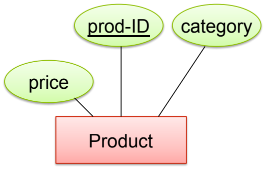


Moral: don't complicate life more than it already is.

From E/R Diagrams to Relational Schema

- Entity set → relation
- Relationship → relation

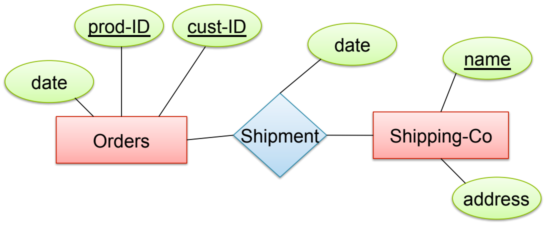
Entity Set to Relation



Product(prod-ID, category, price)

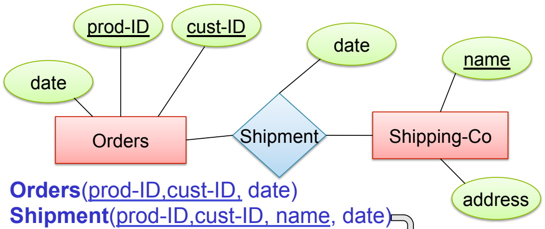
prod-ID	category	price
Gizmo55	Camera	99.99
Pokemn19	Toy	29.99

N-N Relationships to Relations



Represent this in relations

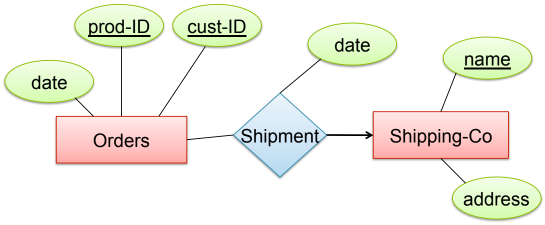
N-N Relationships to Relations



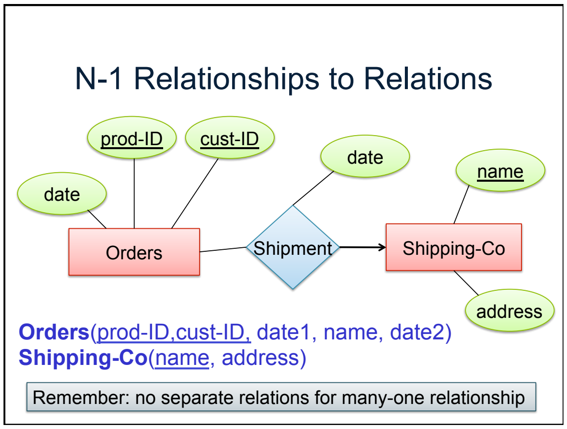
Orders(prod-ID,cust-ID, date)
Shipment(prod-ID,cust-ID, name, date)
Shipping-Co(name, address)

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

N-1 Relationships to Relations



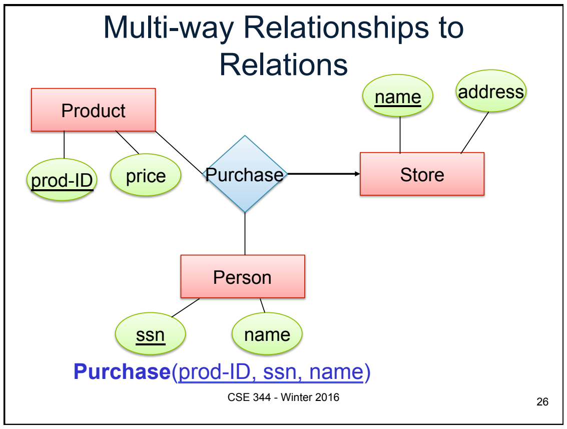
Represent this in relations



N-1 Relationships to Relations

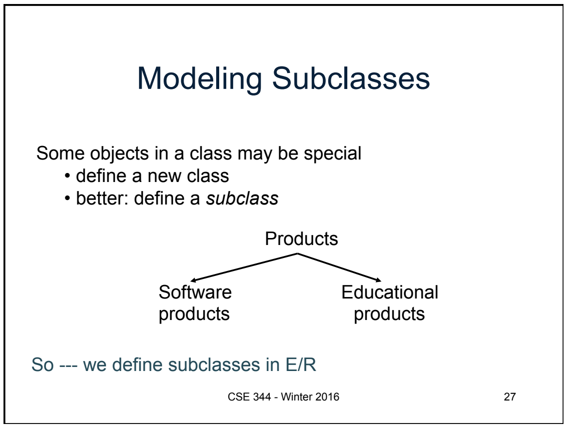
Orders(prod-ID,cust-ID, date1, name, date2)
Shipping-Co(name, address)

Remember: no separate relations for many-one relationship



Multi-way Relationships to Relations

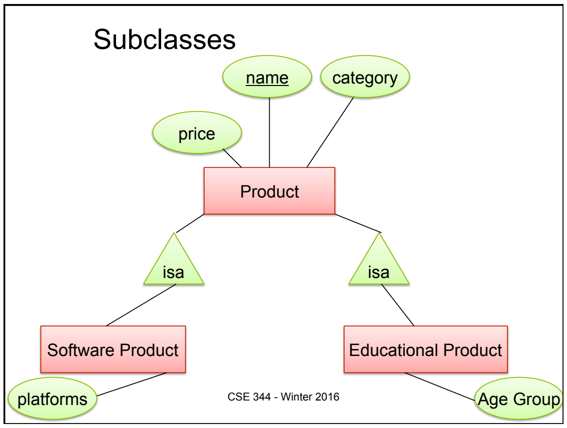
Purchase(prod-ID, ssn, name)



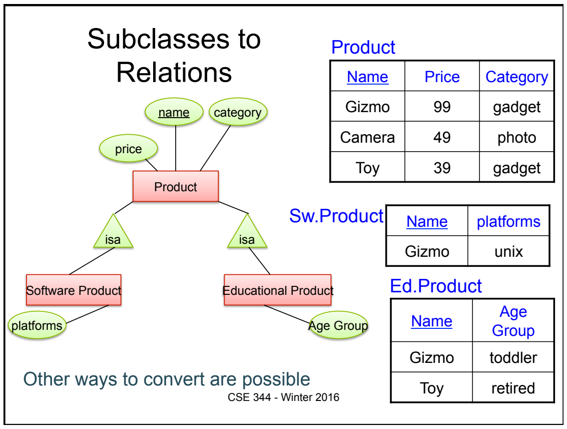
Modeling Subclasses

Some objects in a class may be special
- define a new class
- better: define a *subclass*

So --- we define subclasses in E/R



Subclasses



Subclasses to Relations

Product

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

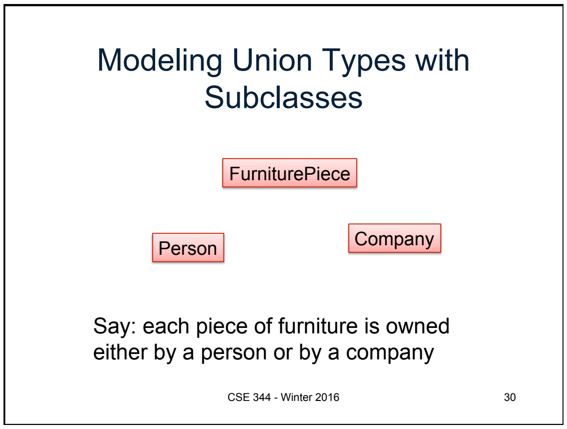
Sw.Product

Name	platforms
Gizmo	unix

Ed.Product

Name	Age Group
Gizmo	toddler
Toy	retired

Other ways to convert are possible



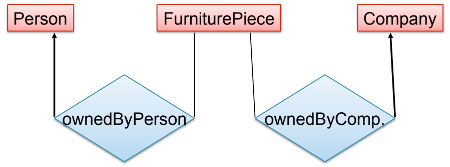
Modeling Union Types with Subclasses

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

Modeling Union Types with Subclasses

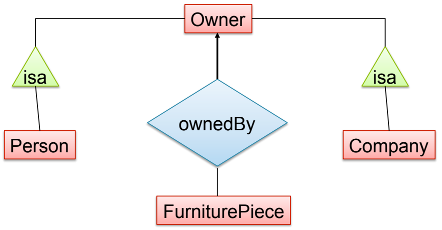
Say: each piece of furniture is owned either by a person or by a company

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



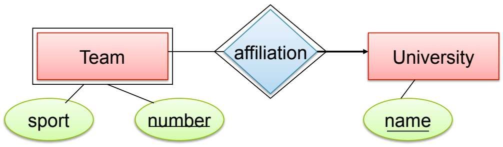
Modeling Union Types with Subclasses

Solution 2: better, more laborious



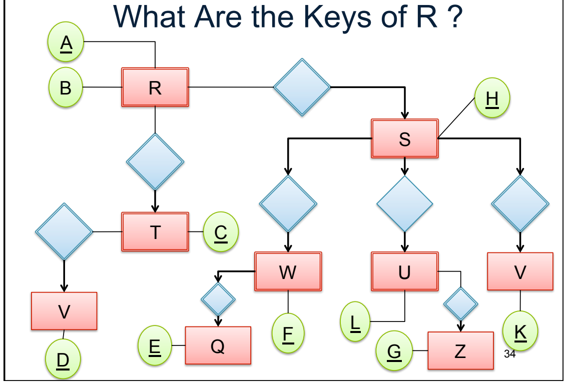
Weak Entity Sets

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

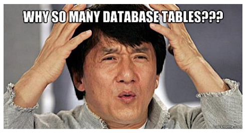


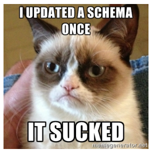
Team(sport, number, universityName)
University(name)

What Are the Keys of R ?



What makes good schemas?





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.

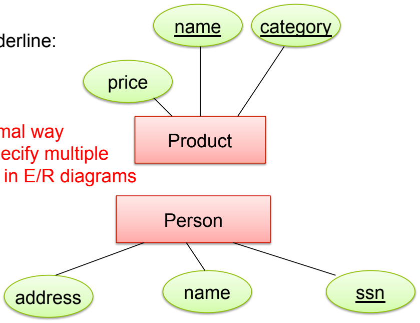
Single-value constraints: a person can have only one father.

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

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

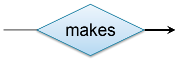
Keys in E/R Diagrams

Underline:

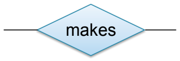


No formal way to specify multiple keys in E/R diagrams

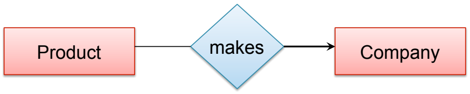
Single Value Constraints



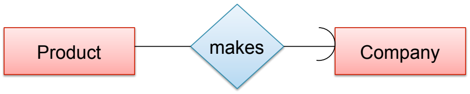
vs.



Referential Integrity Constraints

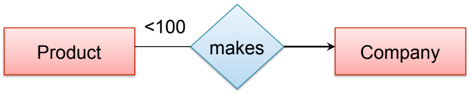


Each product made by at most one company.
Some products made by no company



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

Other Constraints



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

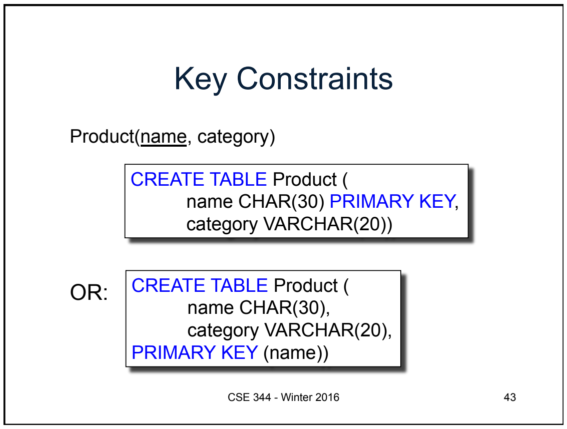
Constraints in SQL

Constraints in SQL:
- Keys, foreign keys
- Attribute-level constraints
- Tuple-level constraints
- Global constraints: assertions

simplest

Most complex

- The more complex the constraint, the harder it is to check and to enforce



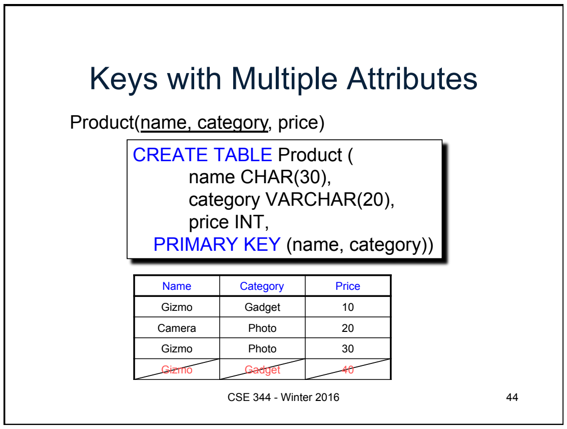
Key Constraints

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

```
CREATE TABLE Product (
        name CHAR(30) PRIMARY KEY,
        category VARCHAR(20))
```

OR:

```
CREATE TABLE Product (
        name CHAR(30),
        category VARCHAR(20),
PRIMARY KEY (name))
```

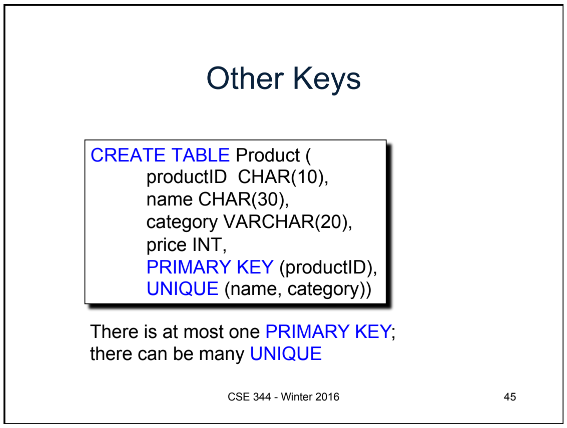


Keys with Multiple Attributes

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

```
CREATE TABLE Product (
        name CHAR(30),
        category VARCHAR(20),
        price INT,
   PRIMARY KEY (name, category))
```

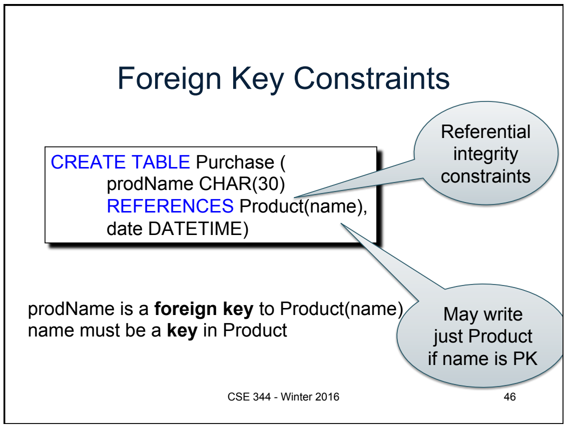
Name	Category	Price
Gizmo	Gadget	10
Camera	Photo	20
Gizmo	Photo	30
~~Gizmo~~	~~Gadget~~	~~40~~



Other Keys

```
CREATE TABLE Product (
        productID  CHAR(10),
        name CHAR(30),
        category VARCHAR(20),
        price INT,
        PRIMARY KEY (productID),
        UNIQUE (name, category))
```

There is at most one PRIMARY KEY;
there can be many UNIQUE



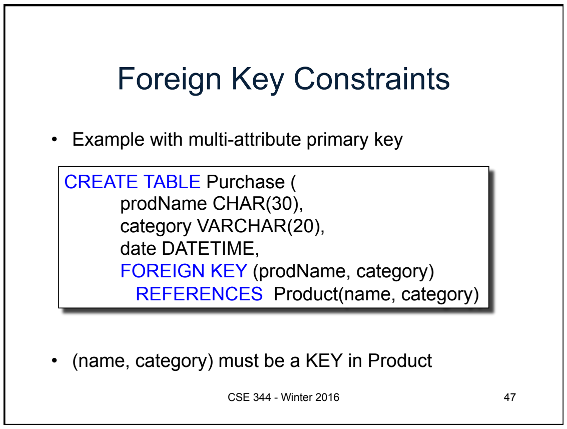
Foreign Key Constraints

```
CREATE TABLE Purchase (
        prodName CHAR(30)
        REFERENCES Product(name),
        date DATETIME)
```

Referential integrity constraints

May write just Product if name is PK

prodName is a **foreign key** to Product(name)
name must be a **key** in Product

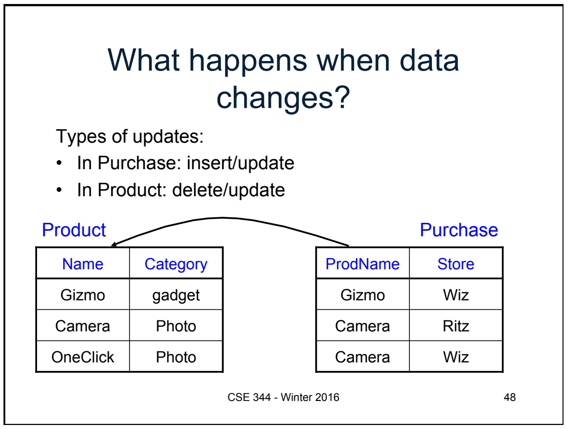


Foreign Key Constraints

- Example with multi-attribute primary key

```
CREATE TABLE Purchase (
        prodName CHAR(30),
        category VARCHAR(20),
        date DATETIME,
        FOREIGN KEY (prodName, category)
          REFERENCES  Product(name, category)
```

- (name, category) must be a KEY in Product



What happens when data changes?

Types of updates:

- In Purchase: insert/update
- In Product: delete/update

Product

Name	Category
Gizmo	gadget
Camera	Photo
OneClick	Photo

Purchase

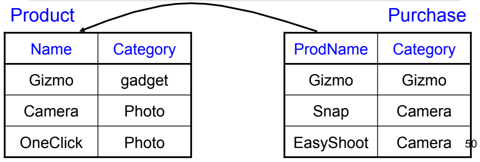
ProdName	Store
Gizmo	Wiz
Camera	Ritz
Camera	Wiz

What happens when data changes?

- SQL has three policies for maintaining referential integrity:
- NO ACTION reject violating modifications (default)
- CASCADE after delete/update do delete/update
- SET NULL set foreign-key field to NULL
- SET DEFAULT set foreign-key field to default value
  - need to be declared with column, e.g., CREATE TABLE Product (pid INT DEFAULT 42)

Maintaining Referential Integrity

```
CREATE TABLE Purchase (
        prodName CHAR(30),
        category VARCHAR(20),
        date DATETIME,
        FOREIGN KEY (prodName, category)
          REFERENCES  Product(name, category)
          ON UPDATE CASCADE
          ON DELETE SET NULL    )
```



Product

Name	Category
Gizmo	gadget
Camera	Photo
OneClick	Photo

Purchase

ProdName	Category
Gizmo	Gizmo
Snap	Camera
EasyShoot	Camera

Constraints on Attributes and Tuples

- Constraints on attributes:
  NOT NULL -- obvious meaning...
  CHECK condition -- any condition !
- Constraints on tuples
  CHECK condition

Constraints on Attributes and Tuples

```
CREATE TABLE R (
            A int NOT NULL,
            B int CHECK (B > 50 and B < 100),
            C varchar(20),
            D int,
            CHECK (C >= 'd' or D > 0))
```

Constraints on Attributes and Tuples

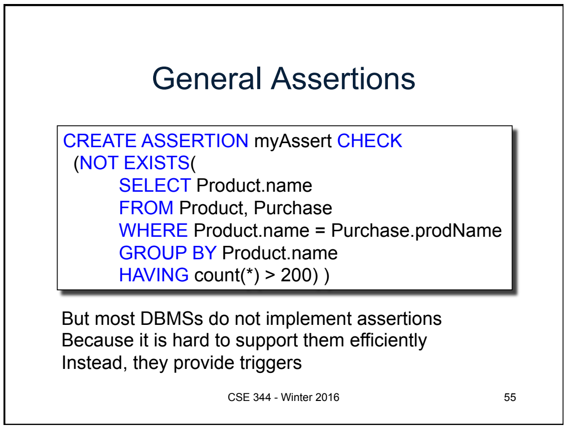
```
CREATE TABLE Product (
        productID  CHAR(10),
        name CHAR(30),
        category VARCHAR(20),
        price INT CHECK (price > 0),
        PRIMARY KEY (productID),
        UNIQUE (name, category))
```

Constraints on Attributes and Tuples

What does this constraint do?

What is the difference from Foreign-Key ?

```
CREATE TABLE Purchase (
        prodName CHAR(30)
            CHECK (prodName IN
                  (SELECT Product.name
                   FROM Product),
        date DATETIME NOT NULL)
```



General Assertions

```
CREATE ASSERTION myAssert CHECK
  (NOT EXISTS(
          SELECT Product.name
          FROM Product, Purchase
          WHERE Product.name = Purchase.prodName
          GROUP BY Product.name
          HAVING count(*) > 200) )
```

But most DBMSs do not implement assertions
Because it is hard to support them efficiently
Instead, they provide triggers