Introduction to Data Management CSE 344

Lecture 16: Constraints

Announcements

- WQ6 due Thursday (there is no WQ5…)
- Homework 4 posted, due Friday
- Midterm: Monday, November 4th, in class

Midterm

- All material up to and including XML
  - SQL, basic evaluation + indexes, RA, datalog-with-negation, RC, XML/XPath/XQuery
- Open books, open notes
  - Don't waste paper printing stuff. Normally, you shouldn't need any notes during the exam. My suggestion is to print, say, 5-6 selected slides from the lecture notes that you had trouble with, and to print your own homework, just in case you forget some cool solution you used there

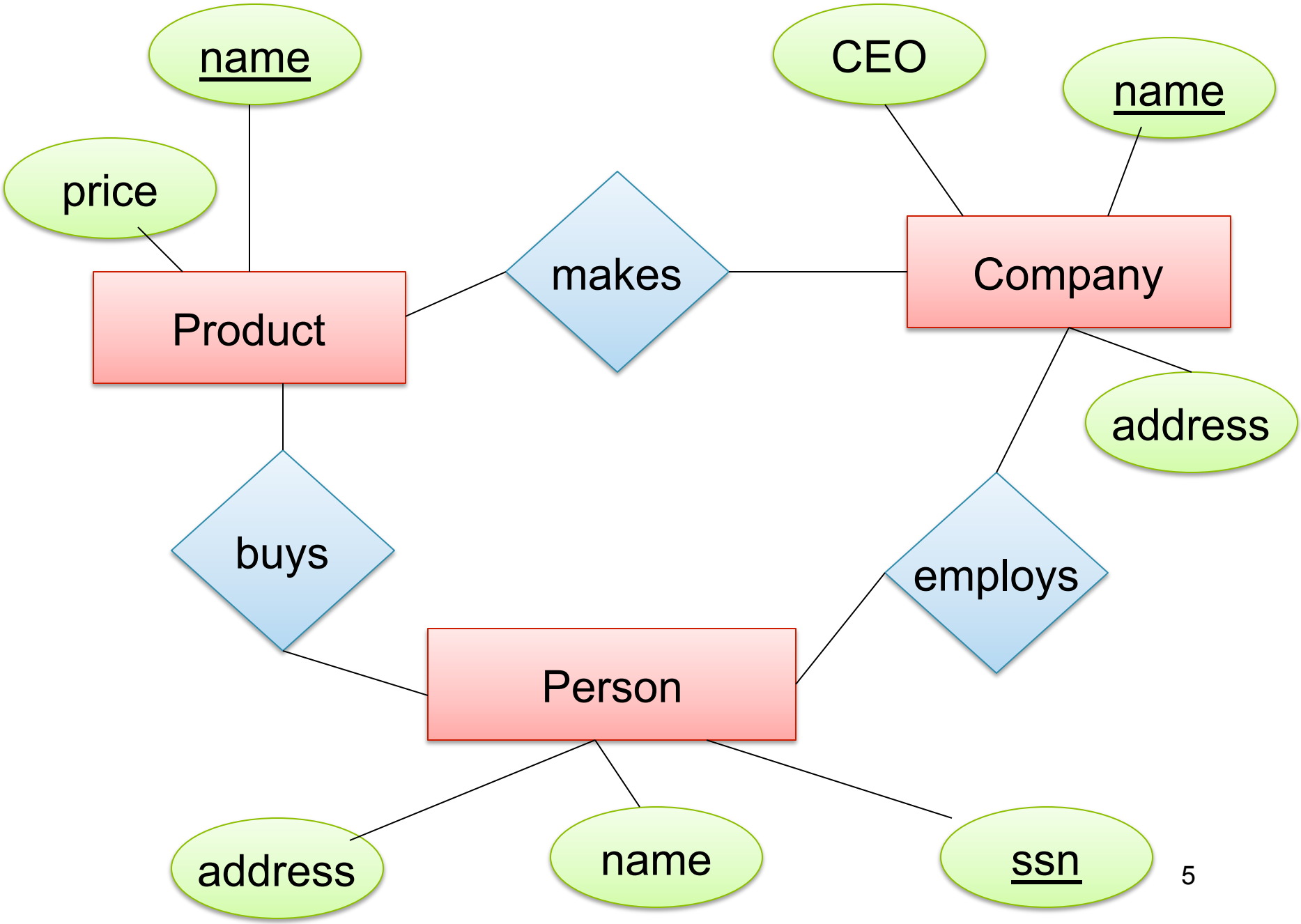
Where We Are?

We are learning about database design

- How to design a database schema?
- Last time: Real world -> ER Diagrams -> Relations

Next, we will learn more about **good** schemas

- Today: Constraints and data integrity
- Next time: Schema normalization, then Views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CEO
name
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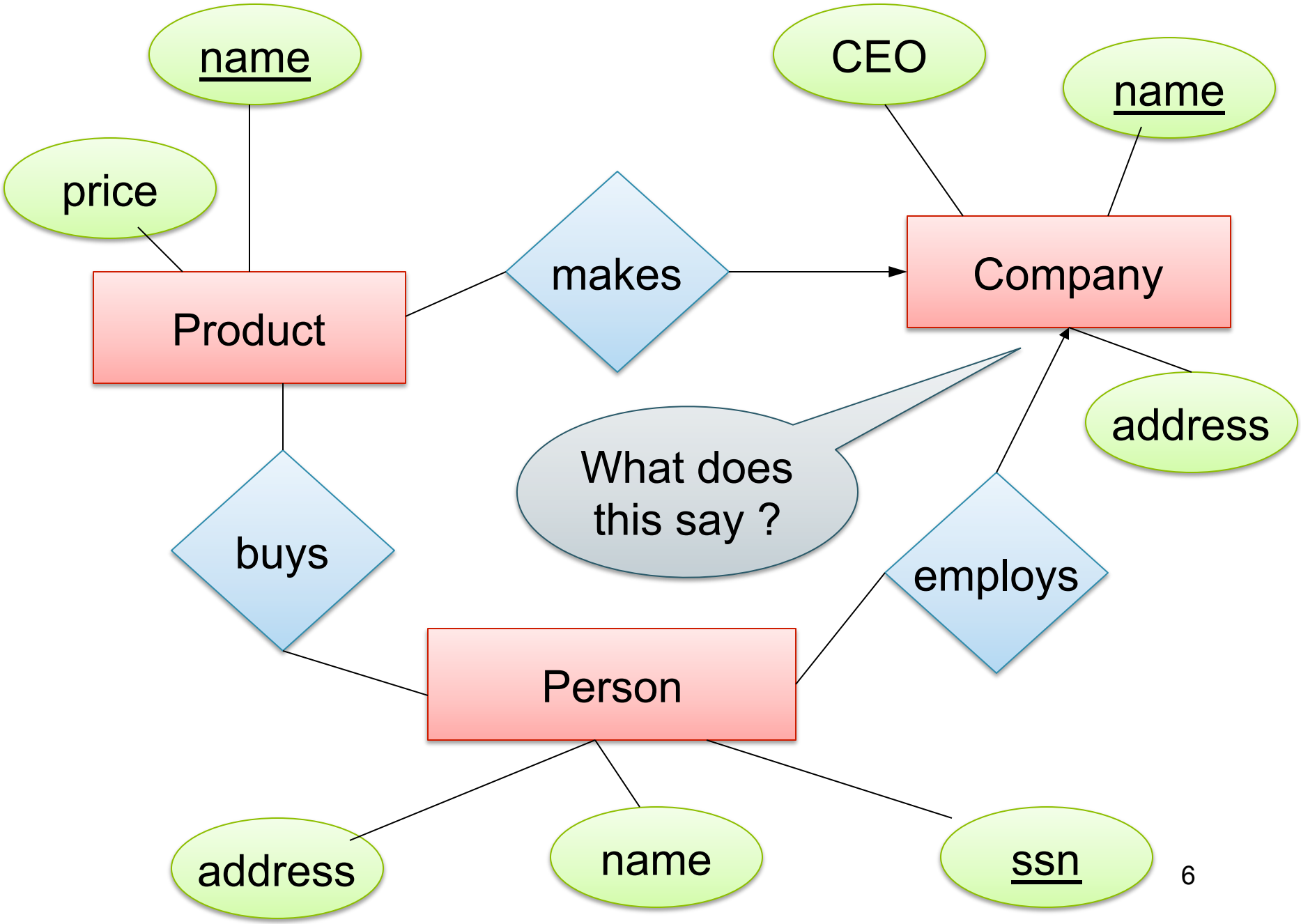
name
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What does this say ?
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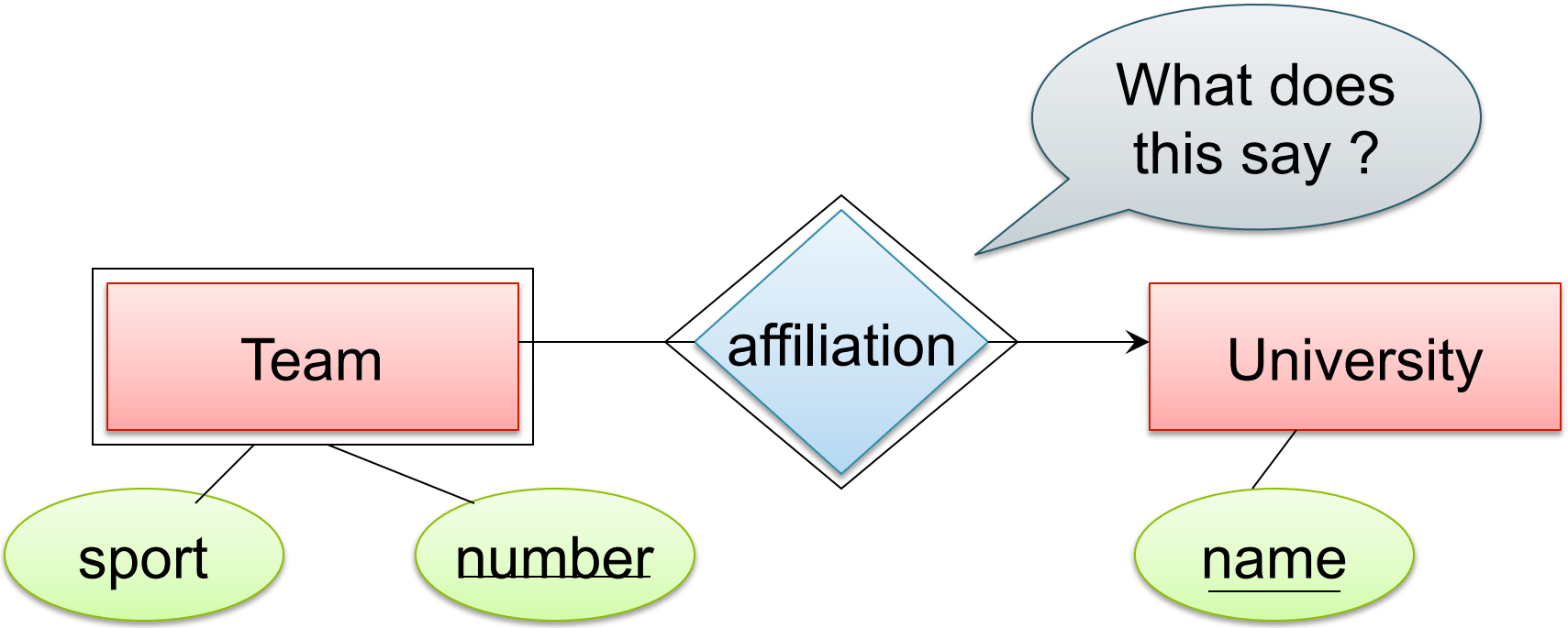
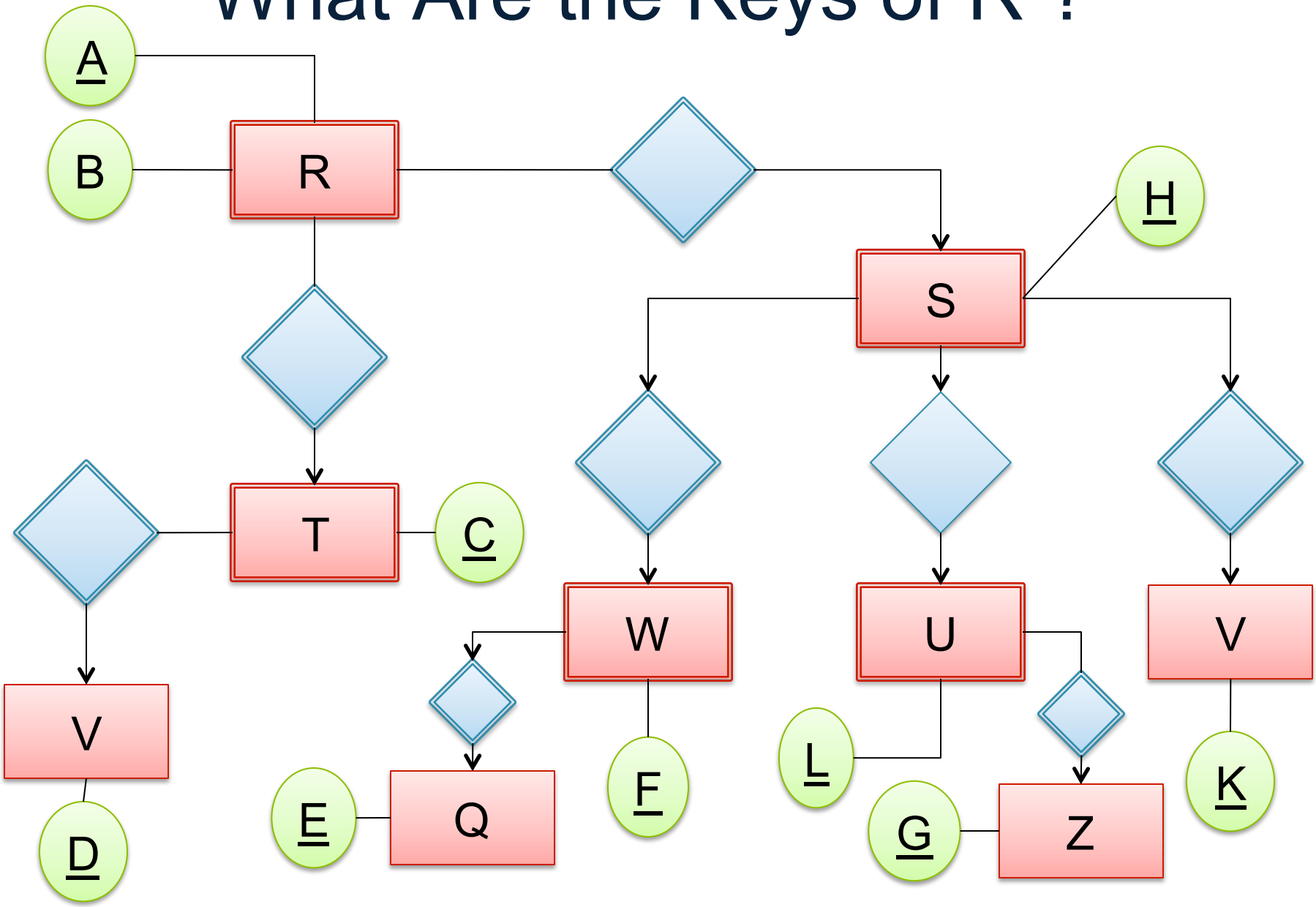
Weak Entity Sets



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

What Are the Keys of R ?



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.

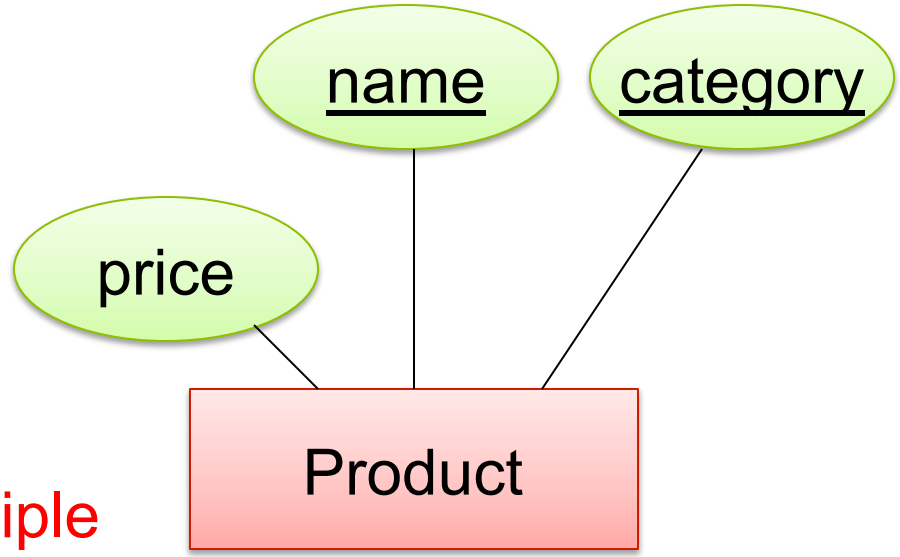
Single-value constraints: a person can have only one father.

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

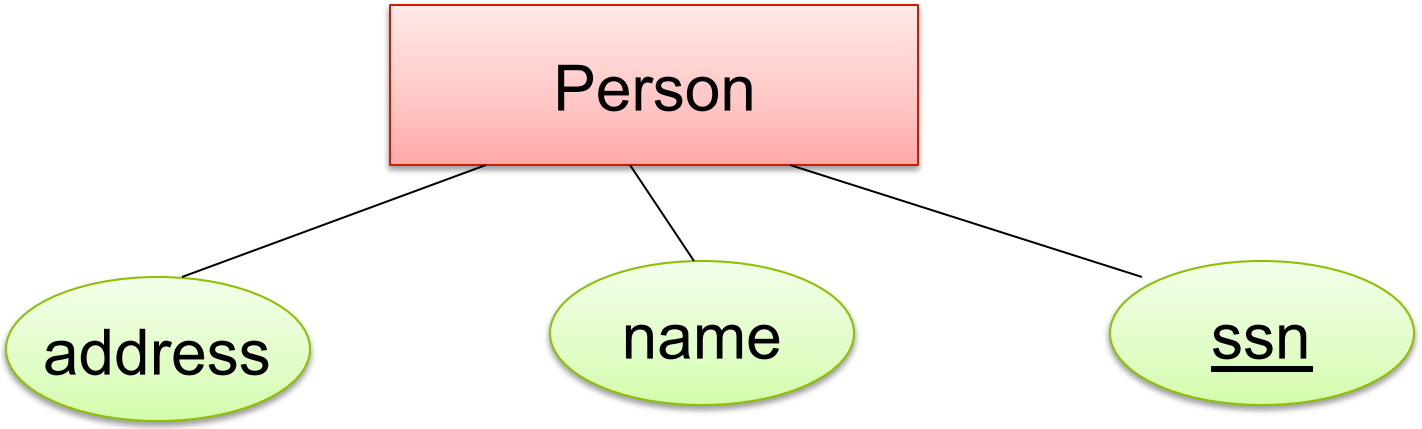
Other constraints: peoples' ages are between 0 and 150.

Keys in E/R Diagrams

Underline:



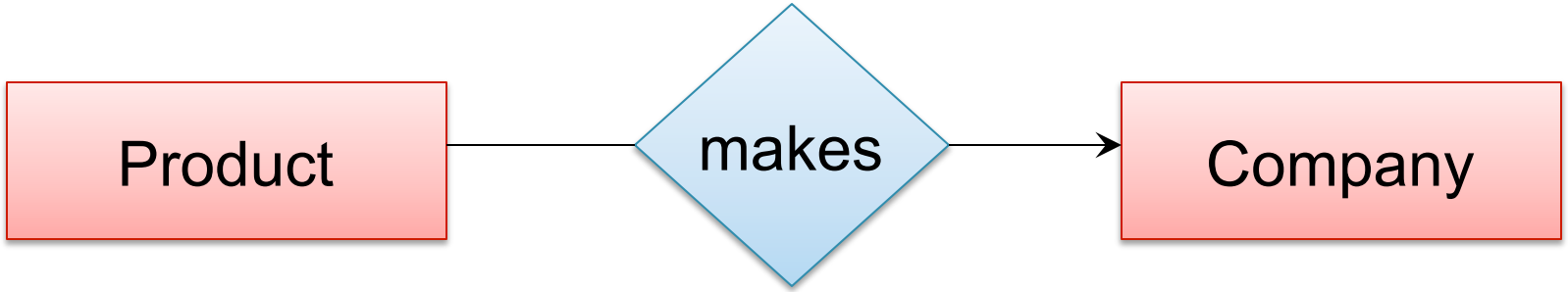
No formal way
to specify multiple
keys in E/R diagrams



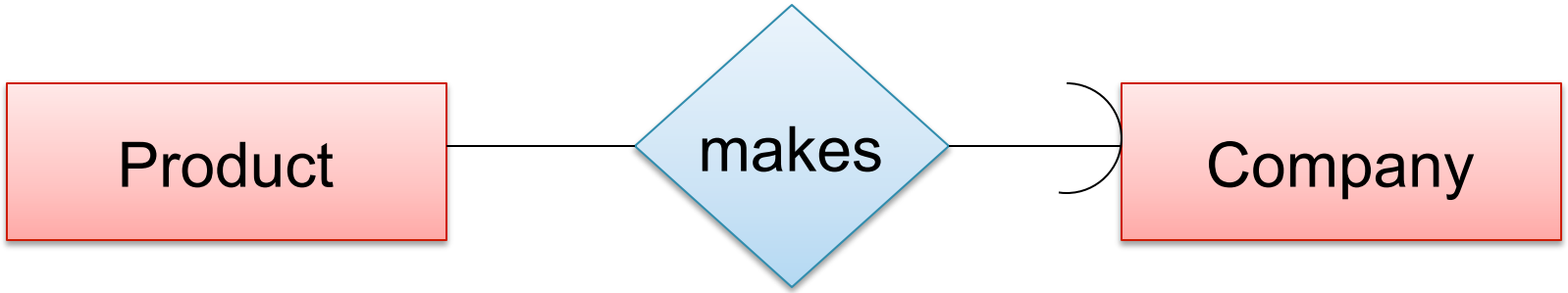
Single Value Constraints

v. s.

Referential Integrity Constraints

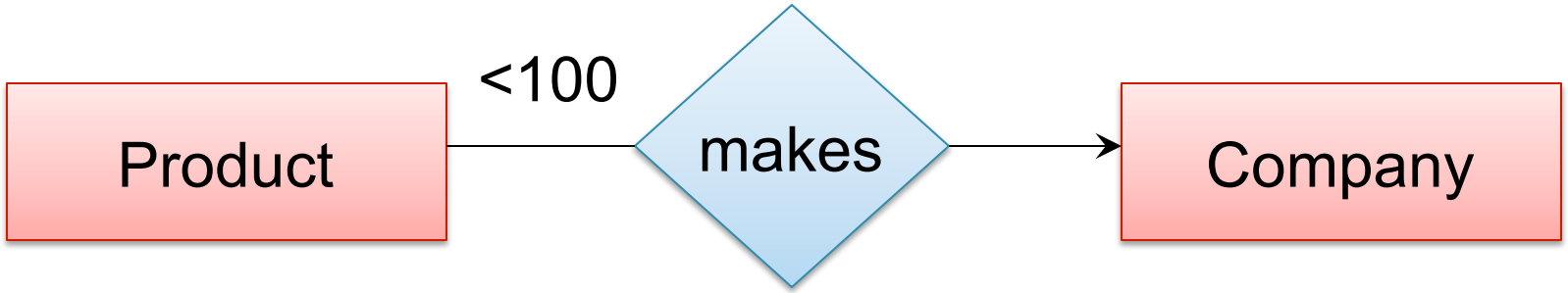


Each product made by at most one company.
Some products made by no company



Each product made by *exactly* one company.

Other Constraints

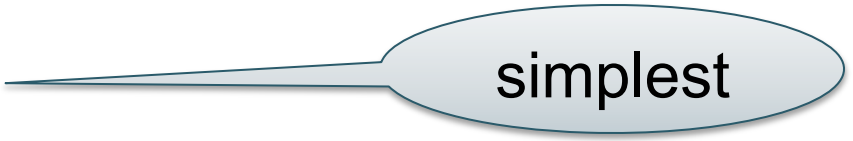


Q: What does this mean ?
A: A Company entity cannot be connected by relationship to more than 99 Product entities

Constraints in SQL

Constraints in SQL:

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



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

Key Constraints

Product(name, 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(name, category, 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

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

May write just Product if name is PK

Foreign Key Constraints

Product

Name	Category
Gizmo	gadget
Camera	Photo
OneClick	Photo

Purchase

ProdName	Store
Gizmo	Wiz
Camera	Ritz
Camera	Wiz

Foreign Key Constraints

- Example with multi-attribute primary key

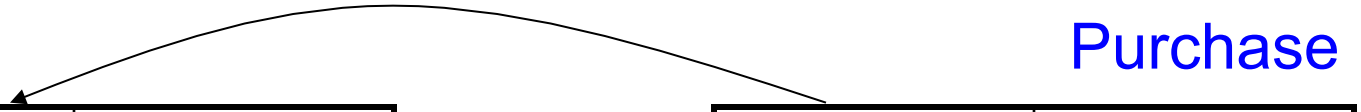
```
CREATE TABLE Purchase (
        prodName CHAR(30),
        category VARCHAR(20),
        date DATETIME,
        FOREIGN KEY (prodName, category)
          REFERENCES  Product(name, category)
```

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

What happens during updates ?

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 during updates ?

- SQL has three policies for maintaining referential integrity:
- Reject violating modifications (default)
- Cascade: after delete/update do delete/update
- Set-null set foreign-key field to NULL

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    )
```

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

Database Triggers

- Event-Condition-Action rules
- Event
  - Can be insertion, update, or deletion to a relation
- Condition
  - Can be expressed on DB state before or after event
- Action
  - Perform additional DB modifications

More About Triggers

- Row-level trigger
  - Executes once for each modified tuple
- Statement-level trigger
  - Executes once for all tuples that are modified in a SQL statement

Database Triggers Example

When Product.price is updated, if it is decreased then set Product.category = ‘On sale’

Database Triggers Example

When Product.price is updated, if it is decreased then set Product.category = ‘On sale’

```
CREATE TRIGGER ProductCategories
AFTER UPDATE OF price ON Product
REFERENCING
    OLD ROW AS OldTuple
    NEW ROW AS NewTuple
FOR EACH ROW
WHEN (OldTuple.price > NewTuple.price)
        UPDATE Product
        SET category = ‘On sale’
        WHERE productID = OldTuple.productID
```

SQL Server Example

```
CREATE TRIGGER ProductCategory
ON Product
AFTER UPDATE
AS
  BEGIN
    UPDATE Product
    SET category='sale' WHERE productID IN
    (SELECT i.productID from inserted i, deleted d
     WHERE i.productID = d.productID
     AND i.price < d.price)
  END
```

Discussion

- Both constraints and triggers are tools that help us keep the database consistent
- What are their pros and cons?