Introduction to Database Systems
CSE 414

Lecture 18: Constraints

Announcements

- HW5 due tonight
- New webquiz out, due Sunday night(!)
  - A little longer than usual and includes things from Friday's lecture
- HW6 out now, due next Wednesday, 11 pm

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

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

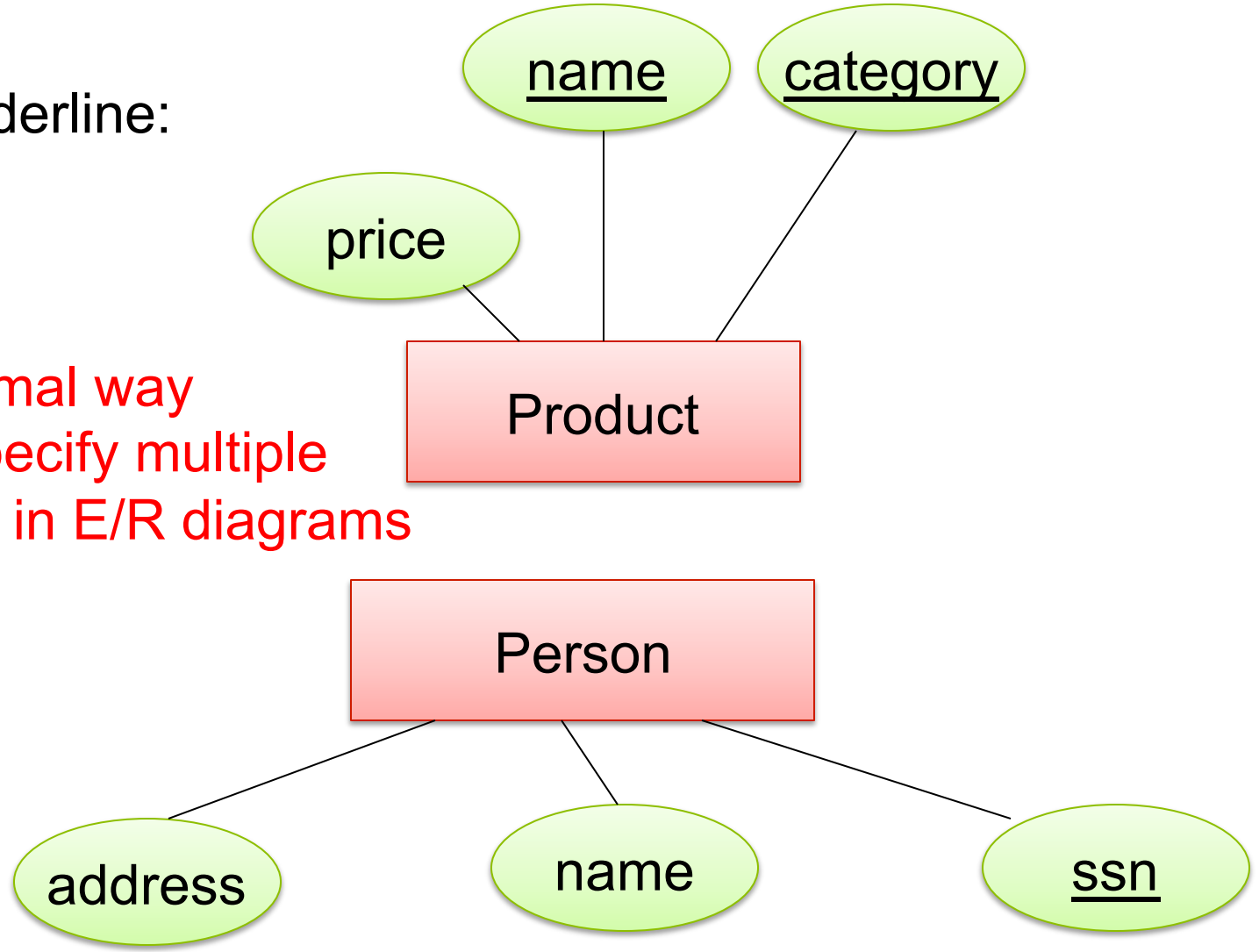
Single-value constraints: a person can have only one father

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:

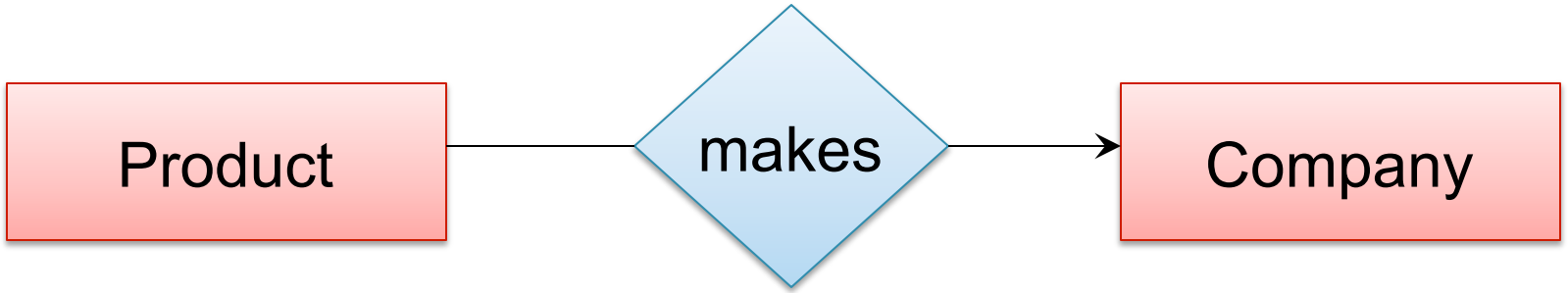


No formal way
to specify multiple
keys in E/R diagrams

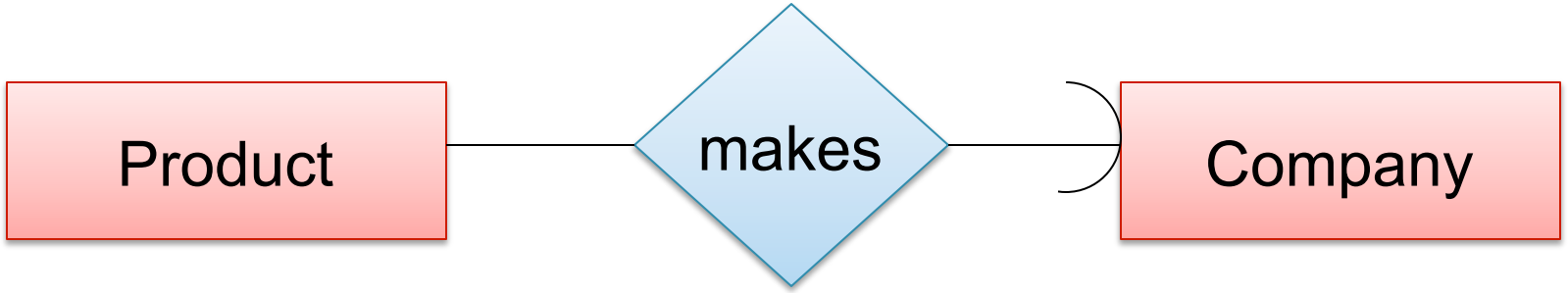
Single Value Constraints

v. s.

Referential Integrity Constraints

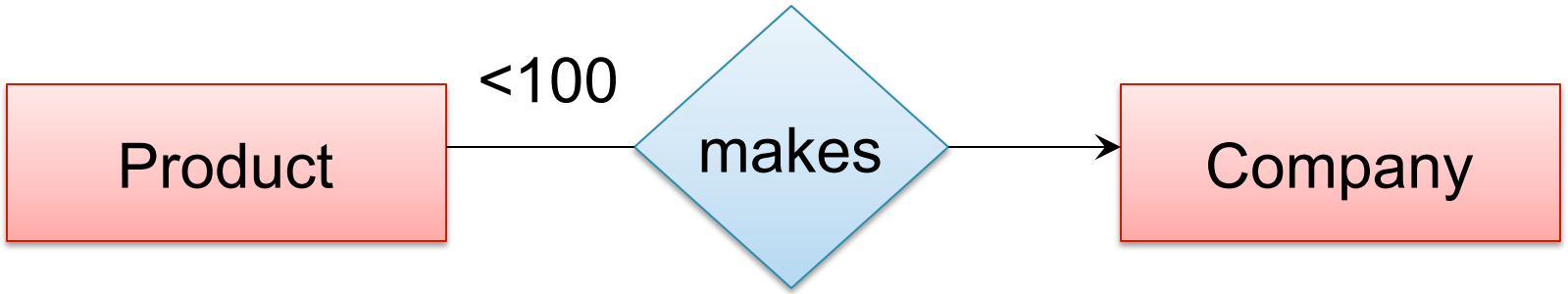


Each product made by at most one company.
Some products made by no company



Each product made by *exactly* one company.

Other Constraints



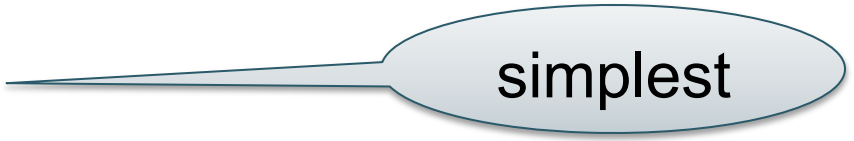
Q: What does this mean ?

A: A Company entity cannot be connected by relationship to more than 99 Product entities

Types of 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))
```

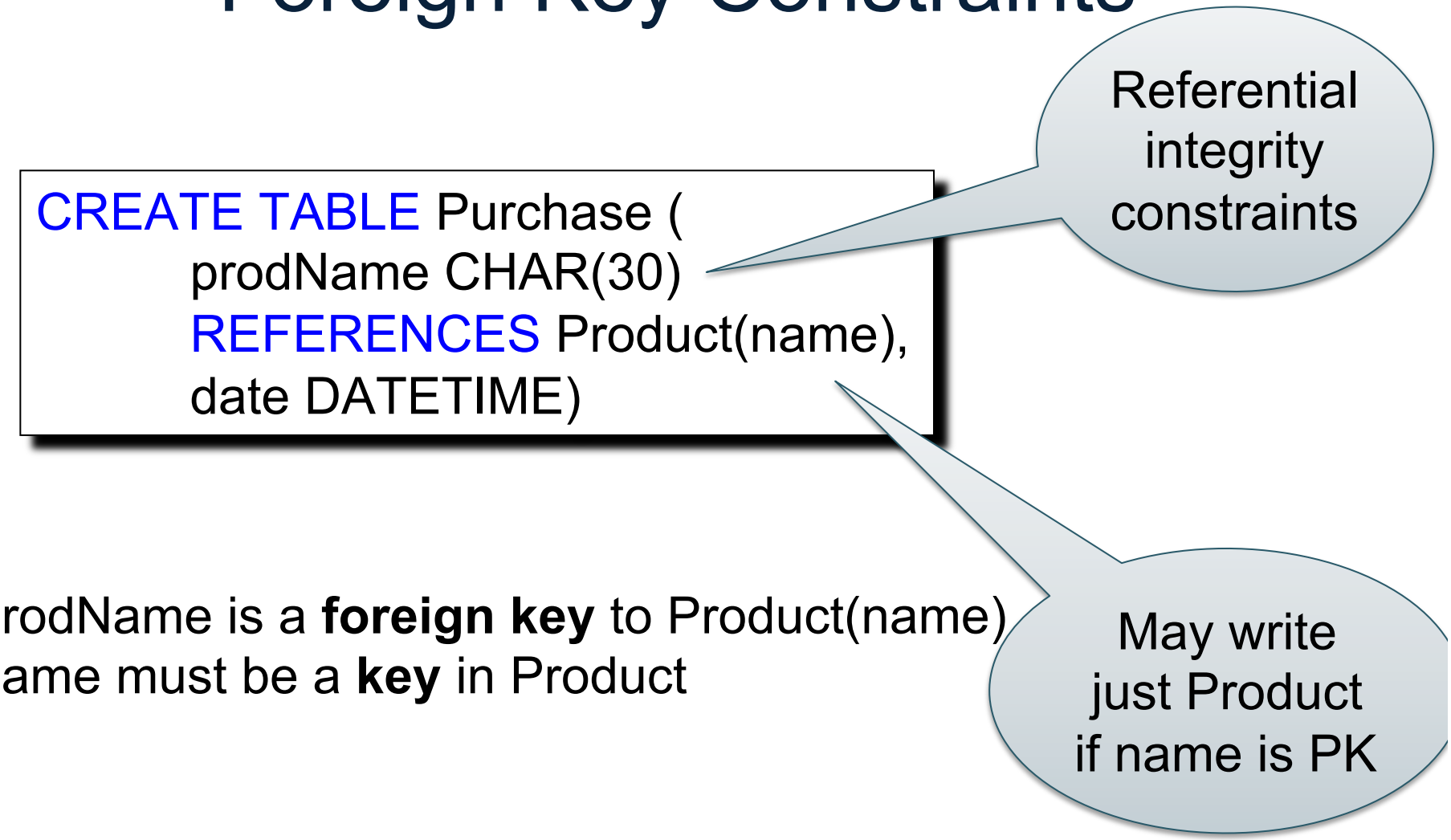
Name	Category	Price
Gizmo	Gadget	10
Camera	Photo	20
Gizmo	Photo	30
~~Gizmo~~	~~Gadget~~	~~40~~

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



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

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

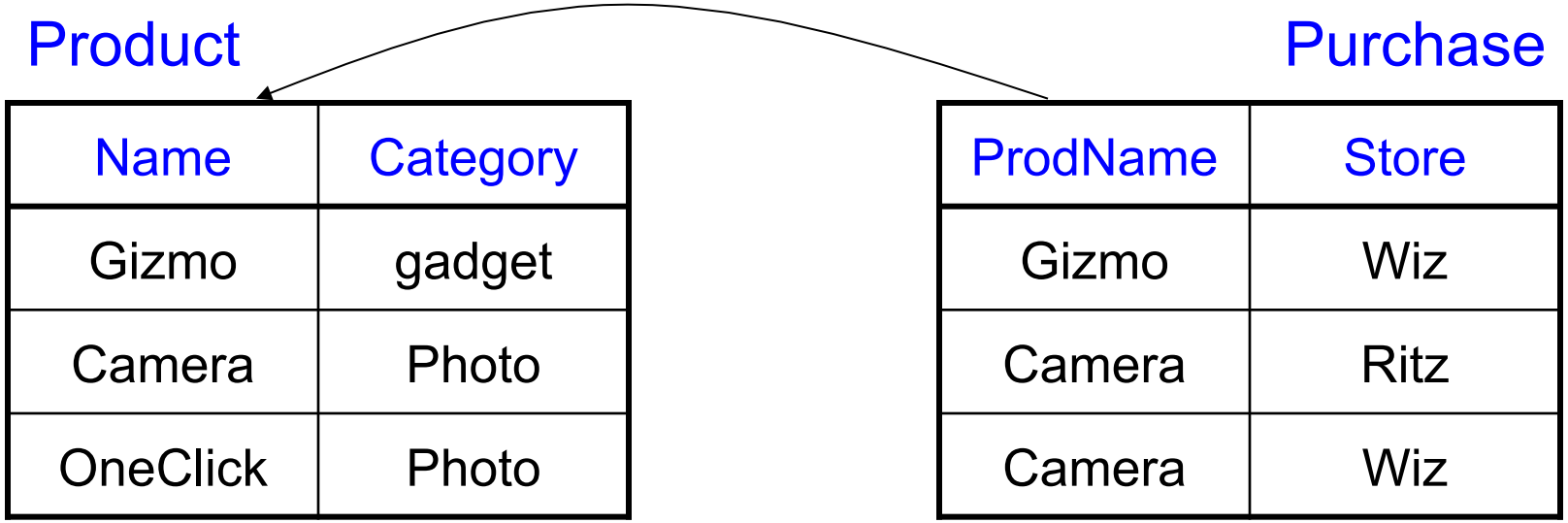
```
CREATE TABLE Purchase (
        prodName CHAR(30),
        category VARCHAR(20),
        date DATETIME,
        FOREIGN KEY (prodName, category)
          REFERENCES  Product(name, category)
```

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

What happens during updates ?

Types of updates:

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



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 anAssert 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

```
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
```