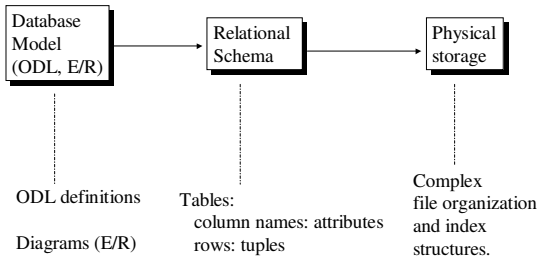
Lecture 5:
The Relational Data Model

Wednesday, October 10, 2001

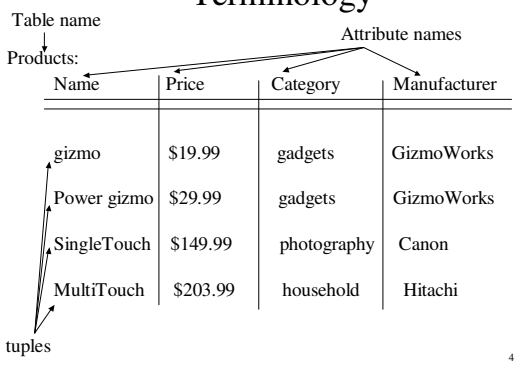
Outline

- The relational model (3.1)
- ODL to relational model (3.2)
- E/R to relational model (3.3)
- Subclasses to relational model (3.4)

The Relational Data Model



Terminology



Domains

- each attribute has a type
- must be atomic type (why ? see later)
- called *domain*
- examples:
  - Integer
  - String
  - Real
  - …

Schemas

Relational Schema:
- Relation name plus attribute names
- E.g. Product(Name, Price, Category, Manufacturer)
- In practice we add the domain for each attribute

Database Schema
- Set of relational schemas
- E.g. Product(Name, Price, Category, Manufacturer),
  Vendor(Name, Address, Phone),
  . . . . . .

Instances

- **Relational schema** = R(A1,…,Ak):
  Instance = relation with k attributes (of "type" R)
  - values of corresponding domains
- **Database schema** = R1(…), R2(…), …, Rn(…)
  Instance = n relations, of types R1, R2, ..., Rn

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Example

Relational schema: Product(Name, Price, Category, Manufacturer)
Instance:

Name	Price	Category	Manufacturer
gizmo	$19.99	gadgets	GizmoWorks
Power gizmo	$29.99	gadgets	GizmoWorks
SingleTouch	$149.99	photography	Canon
MultiTouch	$203.99	household	Hitachi

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Updates

The database maintains a current database state.

Updates to the data:

1) add a tuple
2) delete a tuple
3) modify an attribute in a tuple

Updates to the data happen very frequently.

Updates to the schema: relatively rare. Rather painful. Why**?**

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Schemas and Instances

- Analogy with programming languages:
  - Schema = type
  - Instance = value
- Important distinction:
  - Database Schema = stable over long periods of time
  - Database Instance = changes constantly, as data is inserted/updated/deleted

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Two Mathematical Definitions of Relations

Relation as cartesian product

- Tuple = element of **string** x **int** x **string** x **string**
- E.g. t = (gizmo, 19, gadgets, GizmoWorks)
- Relation = subset of **string** x **int** x **string** x **string**
- Order in the tuple is important !
  - (gizmo, 19, gadgets, GizmoWorks)
  - (gizmo, 19 , GizmoWorks, gadgets)
- No attributes

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Relation as a set of functions

- Fix the set of attributes
  - A={name , price, category, manufacturer}
- A tuple = function t:A → Domains
- Relation = set of tuples
- E.g.

{name → gizmo,
price → 19,
category → gadgets,
manufacturer→gizmoWorks}

- Order in a tuple is not important
- Attribute names are important

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Two Definitions of Relations

- We will switch back and forth between these two:
  - Positional tuples, without attribute names
  - Relational schemas with attribute names

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From ODL to Relational Schema

Start simple: a class definition has only single valued attributes

```
Interface Product{
      attribute float price;
      attribute string name;
      attribute enum {telephony, gadgets, books} category;
}
```

Class becomes a relation, and every attribute becomes a relation attribute:

Product

Name	Price	Category
Gizmo	$19.99	gadgets

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Adding Non atomic Attributes

```
Interface Product{ ...
    attribute struct {string currency, float amount} price;
    ...
}
```

Product

Name	Currency	Amount	Category
Gizmo	US$	19.99	gadgets
Power Gizmo	US$	29.99	gadgets

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Set Attributes

```
Interface Person{
      attribute string name;
      attribute integer SSN;
      attribute set <integer> PhoneNumber;
}
```

One option: have a tuple for every value in the set:

Name	SSN	PhoneNumber
Fred	123-321-99	(201) 555-1234
Fred	123-321-99	(206) 572-4312
Joe	909-438-44	(908) 464-0028
Joe	909-438-44	(212) 555-4000

Disadvantages?

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Modeling Collection Types

The problem becomes even more significant if a class has several attributes that are set types

Question: how bad is the redundancy for *n* set type attributes, each with possibly up to *m* values?

Questions:

- How can we model bags?
- Lists?
- Fixed length arrays?

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Modeling Relationships

```
Interface Product {
      attribute  string name;
      attribute  float  price;
      relationship  <Company>  madeBy;
      }
Interface  Company {
      attribute   string  name;
      attribute   float stock-price;
      attribute   string  address;
  }
```

How do we incorporate the relationship madeBy into the schema?

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Option #1

Product

Name	Price	made-by-name	made-by-stock-price	made-by-address
Gizmo	$19.99	gizmoWorks	0.0001$	Montezuma

What's wrong?

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Hint

```
Interface Product {
        attribute  string name;
        attribute  float   price;
        relationship  Company  madeBy;
        }
Interface  Company {
        attribute   string  name;
        attribute   float stock-price;
        attribute   string  address;
        relationship  set <Product> makes;
  }
```

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Better Solution

Product: (assume: name is a key for company)

Name	Price	made-by-name
Gizmo	$19.99	gizmoWorks

Company:

Name	Stock Price	Address
gizmoWorks	$0.00001	Montezuma

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Additional Issues

1. What if there is no key?
2. What if the relationship is multi-valued?
3. How do we represent a relationship and its inverse?

Answer: that's what we have the book for ☺

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From E/R Diagrams to Relational Schema

Easier than ODL (using a liberal interpretation of the word "easy")

- relationships are already independent entities
- only atomic types exist in the E/R model.

Entity sets ⟶ relations

Relationships ⟶ relations

Special care for weak entity sets.

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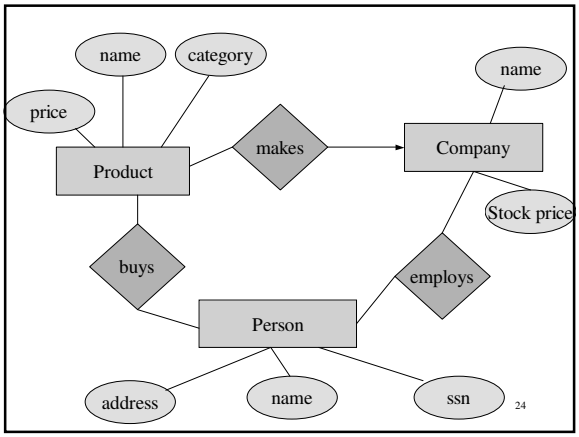

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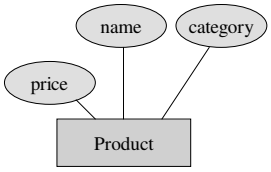
Entity Sets to Relations



Product:

Name	Category	Price
gizmo	gadgets	$19.99

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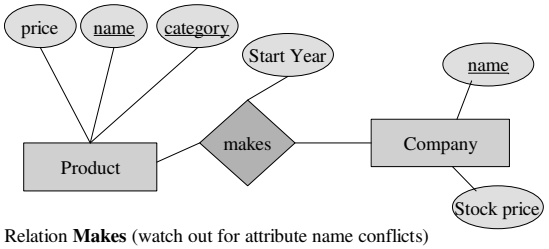
Relationships to Relations



Relation **Makes** (watch out for attribute name conflicts)

Product-name	Product-Category	Company-name	Starting-year
gizmo	gadgets	gizmoWorks	1963

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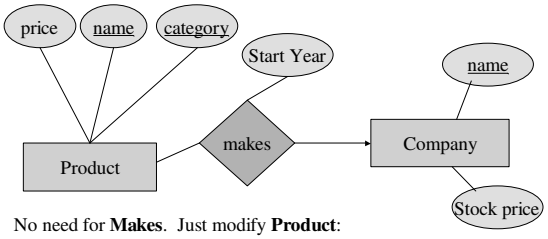
Many-one Relationships



No need for **Makes**. Just modify **Product**:

name	category	price	StartYear	companyName
gizmo	gadgets	19.99	1963	gizmoWorks

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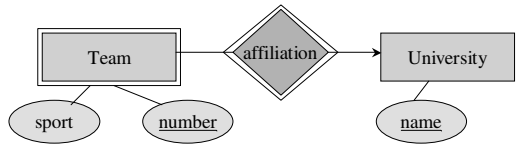
Handling Weak Entity Sets



Relation Team:

Sport	Number	Affiliated University
mud wrestling	15	Montezuma State U.

- need all the attributes that contribute to the key of Team
- don't need a separate relation for Affiliation. (why ?)

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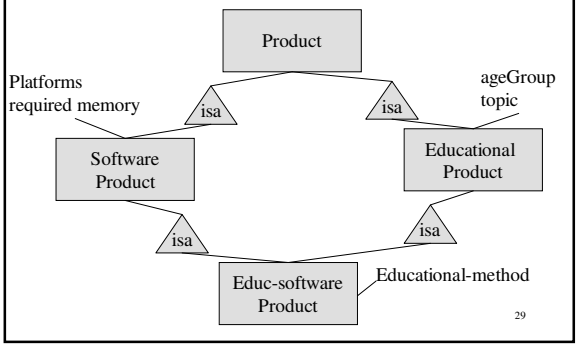
Modeling Subclass Structure



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Option #1: the ODL Approach

4 tables: each object can only belong to a single class

Product(name, price, category, manufacturer)

EducationalProduct(name, price, category, manufacturer, ageGroup, topic)

SoftwareProduct(name, price, category, manufacturer, platforms, requiredMemory)

EducationalSoftwareProduct(name, price, category, manufacturer, ageGroup, topic, platforms, requiredMemory)

All names are distinct

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Option #2: the E/R Approach

Product(name, price, category, manufacturer)

EducationalProduct(name, ageGroup, topic)

SoftwareProduct(name, platforms, requiredMemory)

No need for a relation EducationalSoftwareProduct

Unless, it has a specialized attribute:
EducationalSoftwareProduct(name, educational-method)

Same name may appear in several relations

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Option #3: The Null Value Approach

Have one table:

Product (name, price, manufacturer, age-group, topic, platforms, required-memory, educational-method)

Some values in the table will be NULL, meaning that the attribute not make sense for the specific product.

Too many meanings for NULL

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