Introduction to Database Systems
CSE 414

Lecture 15: E/R Diagrams
Announcements

• Web quiz due Monday night, 11 pm
• Homework 5 due a week from today, 11 pm
• Sections tomorrow: XML, XPath, XQuery

• Today: E/R diagrams (4.1-4.6)
Today: E/R Diagrams

Motivating scenario: your boss asks you to build a DBMS describing:

• Companies. Each company has:
  – A name, an address, and a CEO
  – A list of employees, with ssn, name, and address

• Products manufactured by these companies
  – Each product has a name and a price
  – The same product may be manufactured by several companies

• Buyers of these products
  – Each buyer has an ssn, name, and address
  – Some employees may be buyers too
Database Design

• Why do we need it?
  – Need a way to model real world entities in terms of relations
  – Not easy to go from real-world entities to a database schema
• Consider issues such as:
  – What entities to model
  – How entities are related
  – What constraints exist in the domain
  – How to achieve good designs
• Several formalisms exists
  – We discuss E/R diagrams
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
Keys in E/R Diagrams

• Every entity set must have a key

- Product
  - name
  - price
What is a Relation?

• A mathematical definition:
  – if A, B are sets, then a relation R is a subset of $A \times B$
• $A=\{1,2,3\}$, $B=\{a,b,c,d\}$,
  $A \times B = \{(1,a),(1,b), \ldots, (3,d)\}$
  $R = \{(1,a), (1,c), (3,b)\}$

• makes is a subset of Product $\times$ Company:

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Multiplicity of E/R Relations

- one-one:
  ![Diagram](image1)

- many-one
  ![Diagram](image2)

- many-many
  ![Diagram](image3)
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 $\subseteq \text{Person} \times \text{Product} \times \text{Store}$
Q: What does the arrow mean?

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]
Q: What does the arrow mean?

A: A given person buys a given product from at most one store AND every store sells to every person at most one product
Q: How do we say that every person shops at at most one store?

A: Cannot. This is the best approximation. (Why only approximation?)
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?

Product \(\rightarrow\) Purchase \(\rightarrow\) Person

Country \(\rightarrow\) President \(\rightarrow\) Person

Moral: be faithful to the specifications of the app!
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 $\rightarrow$ relation
- Relationship $\rightarrow$ relation
Entity Set to Relation

**Product** \( (\text{prod-ID}, \text{category}, \text{price}) \)

<table>
<thead>
<tr>
<th>prod-ID</th>
<th>category</th>
<th>price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gizmo55</td>
<td>Camera</td>
<td>99.99</td>
</tr>
<tr>
<td>Pokemn19</td>
<td>Toy</td>
<td>29.99</td>
</tr>
</tbody>
</table>
CREATE TABLE Product (prod-ID CHAR(30) PRIMARY KEY, category VARCHAR(20), price double)
N-N Relationships to Relations

Represent that in relations!
N-N Relationships to Relations

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

<table>
<thead>
<tr>
<th>prod-ID</th>
<th>cust-ID</th>
<th>name</th>
<th>date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gizmo55</td>
<td>Joe12</td>
<td>UPS</td>
<td>4/10/2011</td>
</tr>
<tr>
<td>Gizmo55</td>
<td>Joe12</td>
<td>FEDEX</td>
<td>4/9/2011</td>
</tr>
</tbody>
</table>
CREATE TABLE Shipment(
    name CHAR(30)
    REFERENCES Shipping-Co,
    prod-ID CHAR(30),
    cust-ID VARCHAR(20),
    date DATETIME,
    PRIMARY KEY (name, prod-ID, cust-ID),
    FOREIGN KEY (prod-ID, cust-ID)
    REFERENCES Orders
)

N-1 Relationships to Relations

Represent this in relations!
Orders \( \langle \text{prod-ID, cust-ID, date1, name, date2} \rangle \)

Shipping-Co \( \langle \text{name, address} \rangle \)

Remember: no separate relations for many-one relationship
Multi-way Relationships to Relations

```
Purchase(prod-ID, cust-ssn, store-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

Product

isa

Software Product

platforms

isa

Educational Product

Age Group

name

category

price

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Understanding Subclasses

• Think in terms of records:
  – Product
  – SoftwareProduct
  – EducationalProduct
Subclasses to Relations

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?

A

B

R

T

C

V

D

E

Q

F

W

S

U

L

G

Z

K

H
Where we are

We now have tools for creating models and tables
Next steps are to figure out how to get the right tables and relations given possible choices

Next few lectures:
- Constraints and data integrity
- Schema normalization
- Views