Introduction to Database Systems
CSE 414

Lecture 19: E/R Diagrams

Class Overview

• Unit 1: Intro
• Unit 2: Relational Data Models and Query Languages
• Unit 3: Non-relational data
• Unit 4: RDMBS internals and query optimization
• Unit 5: Parallel query processing
  • Unit 6: DBMS usability, conceptual design
    – E/R diagrams
    – Schema normalization
  • Unit 7: Transactions

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 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
What is a Relation?

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

- $\textit{makes}$ is a subset of $\textit{Product} \times \textit{Company}$:

Multiplicity of E/R Relations

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

Attributes on Relationships

What does this say?
Multi-way Relationships

How do we model a purchase relationship between buyers, products and stores?

Can still model as a mathematical set (How?)

As a set of triples \( \subseteq \text{Person} \times \text{Product} \times \text{Store} \)

Arrows in Multiway Relationships

Q: What does the arrow mean?

A: Any person buys a given product from at most one store

[Fine print: 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]

Converting Multi-way Relationships to Binary

Arrows go in which direction?

Make sure you understand why!

3. Design Principles

What’s wrong?

Moral: Be faithful to the specifications of the application!
Design Principles: What’s Wrong?

Moral: pick the right kind of entities.

Purchase

Stores

Person

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(product-ID, category, 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>

N-N Relationships to Relations

Represent this in relations

Orders(product-ID, cust-ID, date)

Shipment(product-ID, cust-ID, name, date)

Shipping-Co(name, address)
Represent this in relations

Orders\( (\text{prod-ID}, \text{cust-ID}, \text{date1}, \text{name}, \text{date2}) \)

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

Remember: no separate relations for many-one relationship

Multi-way Relationships to Relations

Purchase\( (\text{prod-ID}, \text{ssn}, \text{name}) \)

Try this at home!

Modeling Subclasses

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

Software products
Educational products

So --- we define subclasses in E/R

Subclasses to Relations

Product  Sw.Product  Ed.Product

Other ways to convert are possible

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

Name  platforms
Gizmo  unix

Name  Age Group
Gizmo  toddler
Toy  retired
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?)

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)