The Entity-Relationship Data Model

Chapter 2
(Database Design)

Steps in designing a database

• Analysis:
  – What information needs to be stored?
  – What are the relationships between different components of the stored information?
  – What is the suitable database structure (or schema)?
• Design the database structure (using a database design language or notation suitable for expressing design)
• Implementation in DBMS once committed to the design

Steps in picture

Entity-Relationship Model

• Traditional & popular
• Graphical representation
• Three types of elements
  – Entity set (rectangle)
  – Attributes (oval)
  – Relationship (diamond)

Entity Set

• Collection of similar objects
• Similar to a class in the sense of OOP
• Entity vs. entity set
• Example: Database about movies, their stars, the studio that producing them, and other aspects of movies.
  – A movie is an entity
  – Collection of movies is an entity set
  – Other entities in this db: ?

Attributes

• Entity set has associated attributes
• Each attribute represents a property of entities belonging to the entity set
• Example:
  – The entity set Movies has the associated attribute Title each movie has a title
• Assumption: attributes are atomic values
  address with two components (e.g. number, street) cannot be used as an attribute of an entity set
Relationship

- Connections among entity sets
- Represent a relationship between entity sets
  - If E and F are two entity sets and R connect the two, then R is a binary relation between E and F; mathematically we write \( R \subseteq E \times F \).
- Example: Movies and Stars are two entity sets and a connection Stars-In between the two – the intention: m is related to s means that star s starts in movie m.

E/R Diagram

- A graph representing entity sets, attributes, and relationships.
  - Entity set (rectangle)
  - Attributes (oval)
  - Relationship (diamond)

A reading of the previous diagram

- Three entity sets:
  - Movies [title, year, length, film type]
  - Stars [name, address]
  - Studio [name, address]
- Two relationships
  - (m:n) – Stars_in(Movies, Stars)
  - (m:1) – Owns(Movies, Studios)

Example

- A possible database instance of the previous E/R diagram (Note: The info is inserted for illustrative purpose only – it needs not be true in real life)
A little of math before continuing

- E, F are two sets
  - \( R \subseteq E \times F \): \( R \) is a binary relation from \( E \) to \( F \)
    - \( R \) is a set whose member is a pair \( (e,f) \) where \( e \) is a member of \( E \) and \( f \) is a member of \( F \)
    - \( R \) could be empty, could be equal the Cartesian product of \( E \) and \( F \)
  - \( R \) is many to one relation if for each \( e \) in \( E \) there is at most one element \( (e,f) \) in \( R \)
  - \( R \) is one to one: many to one from \( E \) to \( F \) and many to one from \( F \) to \( E \)
  - \( R \) is many to many: not many to one from \( E \) to \( F \) and not many to one from \( F \) to \( E \)

Multiplicity of Binary E/R Relationship

- \( R \) is a binary relation from \( E \) to \( F \)
  - One to many
  - One to one
  - Many to many
  - Representing using arrow in the connection between entity set and relationship
    - Arrow entering an entity set represents the ‘one’ in the above description

Multiway Relationships

- Easy to handle in E/R diagram: connect all related entity sets with the relationship
  (Note: weakening the relationship (movie,studio))

Roles in Relationship

- An entity set can appear more than one times in a relationship
- E/R diagram: labeling the arc connecting the entity set and the relationship
Another example

Attributes on Relationships

• How to record the salary of a star in a contract?

Attributes on Relationships

• How to record the salary of a star in a contract? Ans: attribute of Contracts!

Eliminating Attributes on Relationship

• Introducing a new entity set whose attributes are the attributes attached to the relationship
• Connecting the new entity set to the relationship, with the arrow pointed to the new entity set
Converting Multiway Relationship to Binary Relationship

• Useful when the language for defining the database structure does not allow multiway relationship.
• Simple:
  – Introducing a new entity set representing the relationship
  – Introducing binary relation between the new entity set and the old ones which are connecting to the relationship

Subclasses in the E/R Model

• Subclass: common in real-life
• Represented by the *isa* relationship
• *isa* is one-one relationship
• In E/R diagram:
  – draw as a triangle
  – no arrows into the entity sets

Design Principles

• Faithfulness
• Avoiding redundancy
• Simple
• Select the right relationships
• Select the right kind of element

Faithfulness

• Entity sets and attributes should reflect reality.
• Relationships are created only if they make sense given what we know about the domain/application.
• Example:
  – *Stars_in* relationship should be many-many
  – *Teaches* relationship between *Courses* and *Instructors*?
    What? How?
No Redundancy

- Motto: Stored everything only one!
- Space reason (less serious)
- Consistency (serious)
- **Example**: Add an attribute `studioName` to the entity set `Movies` while having the relationship `Owns` between `Movies` and `Studios` – consequences:
  - More space (obvious: studio name stored twice)
  - Change in ownership of a movie: change in the `Owns` relationship and the `Movies` entity set

Simplicity

- Do only whatever is necessary!
- **Example**:
  
  ![Diagram](image)
  
  *Assumption*: a star can play in a movie if there is a contract involving the star and the movie. *Stars_in is redundant.*

Right Relationships

- Should we represent every possible relationship? NO: due to space & redundancy requirements & get only the necessarily one
- How? Consider the assumptions, identify those that cannot be deduced from or represented by others

Right Kind of Element

- Attribute vs. Entity set/Relationship
- **Example**: address
  - in the examples so far: attribute
  - better as an entity with attributes such as street, number, zip code, state

**Question**: Would it make sense to have a relationship `Works_for`? Depending …
**Example:** What happens if we replace *Studios* by its two attributes? Redundancy, losing information (if a studio does not own a movie its address is lost).

When to use attribute for entity set E?

- All relationships connecting to E must have an arrow entering E.
- Attributes for E must collectively identify an entity. If there are more than one attributes then they must not depend on each other.
- No relationship involves E more than one.

Converting from Entity sets to Attributes