Database Systems I

Entity Relationship Model

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Entity Relationship Model

✓ The Entity Relationship Model
  • Database design
  • Entity, Entity Set, Attribute, Relationship

• E/R Design Considerations
  • Constraints: Key, Referential, Degree
  • Relationship Conditions: Multiplicity of Relationships, Multiway Relationships

• More E/R Concepts
  • Combining Relations, Constraints, Subclasses, Weak Entity Sets

• Conversion to SQL
Database Design Process

Requirements Analysis

• What data is going to be stored?

• What are we going to do with the data?

• Who should access the data?
Database Design Process

1. Requirements Analysis
2. Conceptual Design
3. Logical, Physical, Security, etc.

Conceptual Design

• A high-level description of the database
• Sufficiently precise that technical people can understand it
• But, not so precise that non-technical people can not participate

✓ Where E/R Model Fits
Database Design Process

Detailed Design

- A Logical Database Design
- Physical Database Design
- Security Design
Entity Relationship Model

• Principal element types

• **Entity**: Individual object

• **Entity Sets**: Collection of similar entities forms an entity set. ER model is a static concept, involving the structure of data and **not the operations on data**

• **Attributes**: Entity sets have attributes, showing properties of the entities in that set

• **Relationships**: Connections among two or more entity sets
Entity Relationship Model

**Example**: Movie Database

- Each movie is an entity, and the set of all movies constitutes an entity set.
- The stars are entities, and the set of stars is an entity set.
- A studio is another kind of entity, and the set of studios is a third entity set.

- The entity set Movies might be given attributes such as title and length.

- Movies and Stars are two entity sets, we could have a relationship Stars-in that connects movies and stars.

- Entities are **not** explicitly represented in E/R diagrams!
ER Diagrams

• A graph representing entity sets, attributes, and relationships
  • Entity sets are represented by rectangles.
  • Attributes are represented by ovals.
  • Relationships are represented by diamonds.

From Chapter 4, The complete book
Keys

• A key is a set of attributes that uniquely identifies an entity.

• Every entity must have a key, although in some cases (we will see later) the key actually belongs to another entity set.

• Denote elements of the primary key by underlining.

• There is no notation for representing the situation where there are several keys for an entity set.

• We underline only the primary key.

• Multiple underlining: they are each member of the key.
Keys

- The attributes `title` and `year` together form the key for `Movies`. 
What is a Relationship?

• Let A and B be sets
  • $A = \{1, 2, 3\}$, $B = \{a, b, c, d\}$

• $A \times B$ (the **cross-product**) is the set of all pairs $(a, b)$
  • $A \times B = \{(1, a), (1, b), (1, c), (1, d), (2, a), (2, b), (2, c), (2, d), (3, a), (3, b), (3, c), (3, d)\}$

• We define a **relationship** to be a **subset** of $A \times B$
  • $R = \{(1, a), (2, c), (2, d), (3, b)\}$
What is a Relationship?

• $A=\{1,2,3\}$  
  $B=\{a,b,c,d\}$

• $A \times B = \{(1,a), (1,b), (1,c), (1,d), (2,a), (2,b), (2,c), (2,d), (3,a), (3,b), (3,c), (3,d)\}$

• $R = \{(1,a), (2,c), (2,d), (3,b)\}$
A relationship between entity sets $P$ and $C$ is a subset of all possible pairs of entities in $P$ and $C$, with tuples uniquely identified by $P$ and $C$'s keys.
What is a Relationship?

<table>
<thead>
<tr>
<th>Company</th>
<th>Product</th>
<th>Company C \times Product P</th>
<th>Makes</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>name</td>
<td>C.name</td>
<td>P.name</td>
</tr>
<tr>
<td>Apple</td>
<td>iPhone 8</td>
<td>Apple</td>
<td>iPhone 8</td>
</tr>
<tr>
<td>Apple</td>
<td>iPad 4</td>
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</tr>
<tr>
<td>Microsoft</td>
<td>Office</td>
<td>Microsoft</td>
<td>Office</td>
</tr>
</tbody>
</table>

Diagram:
- **Product** node with attributes: name, category, price
- **Company** node
- **Makes** relationship between Company and Product
What is a Relationship?

• There can only be one relationship for every unique combination of entities

• This also means that the relationship is uniquely determined by the keys of its entities

• Example: the key for Makes is
  \{Product.name, Company.name\}
Entity Relationship Model

- The Entity Relationship Model
  - Database design
  - Entity, Entity Set, Attribute, Relationship, Key

✓ E/R Design Considerations
  - Constraints: Referential Constraints, Degree Constraints
  - Relationship Conditions: Multiplicity of Relationships, Multiway Relationships

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- Conversion to SQL
Referential Integrity

• A value appearing in one context must also appear in another

• A rounded arrow head pointing to $F$
  • Not only the relationship is many-one from $E$ to $F$
  • But also the entity of set $F$ related to a given entity of set $E$ is required to exist

E/R diagram showing referential integrity constraints
Degree Constraints

• A bounding number on the edges that connect a relationship to an entity set

• Indicates limits on the number of entities that can be connected to any one entity of the related entity set

Representing a constraint on the number of stars per movie
Multiplicity of Binary ER Relationships

- If each member of $E$ can be connected by $R$ to at most one member of $F$: $R$ is many-one from $E$ to $F$.

- If $R$ is both many-one from $E$ to $F$ and many-one from $F$ to $E$: $R$ is one-one.

- If $R$ is neither many-one from $E$ to $F$ nor from $F$ to $E$: $R$ is many-many.

A one-one relationship
Multiplicity of ER Relations

- Usage of arrows

  \[ X \rightarrow Y \] means

  **There exists a function mapping from** \( X \) **to** \( Y \)

  (Recall the definition of a function)
Multiway Relationships

• Relationships involving more than two entity sets

• A multiway relationship in an E/R diagram is represented by lines from the relationship diamond to each of the involved entity sets.

A ternary (three-way) relationship
Roles in Relationships

• It is possible that one entity set appears two or more times in a single relationship.

• Each line to the entity set represents a different role that the entity set plays in the relationship.

• We label the edges between the entity set and relationship by names (roles).
Attributes in Relationships

• It is never necessary to place attributes on relationships.

• Could be replaced by a new entity set with the attributes.

A relationship with an attribute
Attributes in Relationships

Moving the attribute to an entity set

From Chapter 4, The complete book
A Note on Different Notations

Each product made by at most one company.

Referential Integrity.

Each product made by exactly one company.
Acknowledgements

I have used materials from the following resources in preparation of this course:

• **Database Systems: The Complete Book**
• Database Systems (Kifer, Bernstein, Lewis)
• Database System Concepts: [https://www.db-book.com](https://www.db-book.com)
• Course offerings
  • **CMPT 354 (Jiannan Wang - SFU):** [https://sfu-db.github.io/cmpt354/](https://sfu-db.github.io/cmpt354/)
  • W 4111 (Eugene Wu - Columbia): [https://w4111.github.io/](https://w4111.github.io/)
  • CS 186 (Joe Hellerstein - Berkeley): [https://sites.google.com/site/cs186fall17/](https://sites.google.com/site/cs186fall17/)