Entity-Relationship Modeling: RELATIONSHIPS

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Topics

• Relationships
• Structural Constraint
• (min,max) Notation
• Translation into Relational Tables
Relationship

- Entities may be related to one another, each entity takes a role in the relationship.
  
  Example: a course, a teacher, and a student may be related – the student is taking the course taught by the teacher.

- The number of roles (therefore entities, in general) involved is called the degree of the relationship.

- In our ER modeling, we only need to focus on:
  
  – relationships of a fixed degree;
  
  – relationships of degree 2, binary relationships.

- Justification: sufficient, and readily implementable.

Relationship Instances...

- course
  
  title: DB Mgt Sys
  number: 4240

- course
  
  title: E-Business
  number: 4249

- teaches
  
  (P. Laverty, 4249)

- teaches
  
  (P. Wu, 4240)

- teacher
  
  name: P. Laverty
  phone: x 9420

- teacher
  
  name: P. Wu
  phone: x 9427
Relationship Set in ER Model

- A **relationship set** is represented as a *diamond* in the ER diagram, connecting entity sets.
- We *may* label the roles along the connecting lines.

![ER Diagram for teaches relationship](image)

Relationship and Relationship Set

- A **relationship** is a generic description of the nature of a relationship between the entity types.
- A **relationship instance** brings together the *specific* entities which are related by the relationship.
- A **relationship set** is the collection of all the relationship instances of the relationship type.

![ER Diagram for takes relationship](image)
Relationship and Attributes

- A Relationship may have attributes, too.
- Identifies a property or characteristic of each instance of the relationship type…

- The *due date* is an attribute in each *instance* of a patron taking out a book on loan.

Relationship and Attributes

Each competitor will compete and get rated by a panel of judges, each giving a score…
Relationship and Roles

- The same entity set can be related to the same relationship set; note the different roles.

![Relationship Diagram]

Relationship and Roles

- The same two entity sets can be related to each other in two different relationship sets.

![Relationship Diagram]
Structural Constraints

• The information structure depicted in our ER model may have certain constraints, pertaining to the nature of the relationships in the model:
  – Participation Constraint: about how the entity sets are participating in the relationship.
  – Cardinality Constraint: about the ratio of the number of entities in each entity sets being related.
• Collectively, these are known as the structural constraints of the Entity-Relationship model.

Participation Constraint

When an entity set participates in a relationship, it may participate partially, or totally.
• Partial Participation: some entities of the set do not participate in any relationship instance.
• Total Participation: every entity of the set participate in at least one relationship instance.
Partial Participation

- Example of *partial participation*: some employees may not work on any project. The entity set Employee participates partially in the relationship "works on".
- But we *may* not allow a project with no employees.

Total Participation

- Every project must have at least one employee.
- The entity set Project *participates totally* in the "works on" relationship: a double connection line.
Cardinality Ratio: 1-to-1

- When an entity set participates in a (binary) relationship, the cardinality ratio specifies the ratio between number of related entities in the relationship.
- For example: at most one manager for every department, and a manager manages no more than one department. one-to-one.

Cardinality Ratios

- There may be other forms of ratios...
- We label only these forms – 1:1, 1:M, M:1, M:M.
- Many employees may serve the same department, but each employee may not serve more than one department.
Cardinality Ratio: M-to-M

- An example of M:M ratio – an employee may work on more than one project; any project may have more than one employee working on it. M-to-M.

Cardinality Ratio and Participation

- Two *different dimensions* of the constraints on a relationship: *any* combination is possible.
Cardinality and Participation

- Every department must have at least one employee.
- Every employee must serve exactly one department.
- There may be many employees serving one department.

Structural Constraints: \((\text{min},\text{max})\) notation

- We may label participation in a relationship \((\text{min},\text{max})\) to specify the range for each entity in the participation: min/max is an integer value or * - an arbitrary number.
Structural Constraints: \((\text{min}, \text{max})\) notation

- An employee may serve no department; \(\text{min}=0\).
- An employee may serve at most one department; \(\text{max}=1\).
- A department must have at least one employee; \(\text{min}=1\).
- A department may have up to any number of employees; \(\text{max}={}^*\).

Two notations are related...

- The \(\text{min}\) value of 0 implies partial participation.
- The \(\text{min}\) value of 1 or larger implies total participation.
- What can we say about the \(\text{max}\) values and cardinality ratios?
Two notations are related...

- The max values on both sides indicate the cardinality ratio.
- The min value on either side has nothing to do with cardinality ratio.
- 
  vs 
  on both sides indicates one-to-one relationship.
- 
  vs 
  on both sides indicates many-to-many relationship
  … The max value of 2 or larger works the same way as .

- 
  vs 
  in that direction indicates one-to-many relationship.
- 
  vs 
  in that direction indicates many-to-one relationship.

Relationship to Tables

- A relationship set may or may not be translated into a table.
Relationship to Tables

- If each course is taught by at most one instructor.

<table>
<thead>
<tr>
<th>instructor</th>
<th>course</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>phone</td>
</tr>
<tr>
<td>Laverty</td>
<td>9429</td>
</tr>
<tr>
<td>Wu</td>
<td>9426</td>
</tr>
<tr>
<td>number</td>
<td>title</td>
</tr>
<tr>
<td>4240</td>
<td>Database Management</td>
</tr>
<tr>
<td>4244</td>
<td>Document Processing</td>
</tr>
<tr>
<td>4249</td>
<td>Electronic Business</td>
</tr>
</tbody>
</table>

- An additional column to the course table suffices.

Relationship to Tables

- If a course may be taught by more than one instructor, we may need to create another table.

<table>
<thead>
<tr>
<th>instructor</th>
<th>course</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>phone</td>
</tr>
<tr>
<td>Laverty</td>
<td>9429</td>
</tr>
<tr>
<td>Wu</td>
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<td>Document Processing</td>
</tr>
<tr>
<td>4249</td>
<td>Electronic Business</td>
</tr>
</tbody>
</table>
Relationship to Tables

- Use another table for the relationship set...

<table>
<thead>
<tr>
<th>instructor</th>
<th>teaches</th>
<th>course</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>number</td>
<td>title</td>
</tr>
<tr>
<td>Laverty</td>
<td>9429</td>
<td>4240</td>
</tr>
<tr>
<td>Wu</td>
<td>9426</td>
<td>4244</td>
</tr>
</tbody>
</table>

- Note how the keys from the entity sets work for the relationship set in the table.

Relationship: M-to-M

- Create a new table for the relationship.
- Combine keys from both Entity Sets to be its Key.
- Add a column for each of its own attributes.
Relationship: 1-to-M or M-to-1

- No new table necessary (unless preferred).
- Extend table on the M-side (in this case \(E_2\)), with total participation.
- Add a column for each of the key attributes of \(E_1\).
- Add a column for each attribute of relationship \(R\).

\[
\begin{array}{ccc}
E_1 & \overset{1:1}{} & E_2 \\
\hline
k_1 & a_1 & k_2 \\
\cdots & \cdots & \cdots \\
\cdots & \cdots & \cdots \\
\end{array}
\]

\[
\begin{array}{cccc}
E_2 (extended for R) & \\
\hline
k_2 & a_2 & k_1 & a_3 \\
\cdots & \cdots & \cdots & \cdots \\
\cdots & \cdots & \cdots & \cdots \\
\end{array}
\]

Relationship: 1-to-1

- Extend either table or both tables; if total participation.
- Add a column (to an extended table) for each key attributes of the other entity set (to both tables, if both extended).
- For each attribute of relationship \(R\), add a column to either one of the extended tables.

\[
\begin{array}{ccc}
E_1 (extended for R) & \overset{1:1}{} & E_2 \\
\hline
k_1 & a_1 & k_2 \\
\cdots & \cdots & \cdots \\
\cdots & \cdots & \cdots \\
\end{array}
\]

\[
\begin{array}{cccc}
E_2 (extended for R) & \\
\hline
k_2 & a_2 & k_1 & a_4 \\
\cdots & \cdots & \cdots & \cdots \\
\cdots & \cdots & \cdots & \cdots \\
\end{array}
\]