The Entity-Relationship Model Continued

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Roles in Relationships

- Can the same entity set appear more than once in the same relationship?
Roles in Relationships

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- Prerequisite relationship between two Courses

- Which course is the pre-requisite?
Roles in Relationships

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- Label the lines connecting entity to relationship with the role of the entity.
Parallel Relationships

- Can there be more than one relationship between the same pair of entities?
Parallel Relationships

- Can there be more than one relationship between the same pair of entities?

- TA and Take relationship between Students and Classes
Are Attributes on Relationships Needed?

We can convert the attribute to an entity and make the relationship multiway.
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Multiway Relationships

- Relationships may connect more than two entity sets.
- Consider scenario two in the handout: \( \geq 1 \) professor can teach a course but each student evaluates each professor separately.
Multiway Relationships

- Relationships may connect more than two entity sets.
- Consider scenario two in the handout: \( \geq 1 \) professor can teach a course but each student evaluates each professor separately.
- Three-way *Evaluation* relationship between *Students*, *Professors*, and *Classes*.

![Diagram of multiway relationships between Students, Professors, Courses, Evaluation, and Grade](image-url)
Another Multiway Relationship

- Consider scenario three in the handout: $\geq 1$ professor can teach a course but each student taught by at most one professor, and each student only evaluates that professor.
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Add arrow directed towards Professors.
Multiplicity in Multiway Relationships

- An arrow pointing to an entity set $E$ $\Rightarrow$ if we select an entity from each of the other entity sets, the selected entities are related to at most one entity in $E$. 

![E/R diagram](image-url)
Multiplicty in Multiway Relationships

- An arrow pointing to an entity set $E \Rightarrow$ if we select an entity from each of the other entity sets, the selected entities are related to at most one entity in $E$.

```
<table>
<thead>
<tr>
<th>Student</th>
<th>Course</th>
<th>Professor</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hermione Grainger</td>
<td>Potions</td>
<td>Snape</td>
<td>F-</td>
</tr>
<tr>
<td>Draco Malfoy</td>
<td>Potions</td>
<td>Snape</td>
<td>A*</td>
</tr>
<tr>
<td>Harry Potter</td>
<td>Potions</td>
<td>Lupin</td>
<td>A+</td>
</tr>
<tr>
<td>Ron Weasley</td>
<td>Potions</td>
<td>Lupin</td>
<td>B+</td>
</tr>
</tbody>
</table>
```

- E/R diagram forbids connections between “Hermione Grainger,” “Potions” and two different professors.
It is easy to convert a multiway relationship to multiple binary relationships.

- Create a new connecting entity set. Think of its entities as the tuples in the relationship set for the multiway relationship.
- Introduce relationships from the connecting entity set to each of the entities in the original relationship.
- If an entity set plays > 1 role, create a relationship for each role.
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- If an entity set plays > 1 role, create a relationship for each role.

What is the multiplicity of each of the new relationships?
Example of the Conversion

Instance of *Evaluation* (ternary) relationship before conversion:

<table>
<thead>
<tr>
<th>Student</th>
<th>Course</th>
<th>Professor</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
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<td>Potions</td>
<td>Lupin</td>
<td>B+</td>
</tr>
</tbody>
</table>

*Evaluation* entity set after conversion:

<table>
<thead>
<tr>
<th>Eval_Id</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>e1</td>
<td>F-</td>
</tr>
<tr>
<td>e2</td>
<td>A*</td>
</tr>
<tr>
<td>e3</td>
<td>A+</td>
</tr>
<tr>
<td>e4</td>
<td>B+</td>
</tr>
</tbody>
</table>

*Student_of* entity set after conversion:

<table>
<thead>
<tr>
<th>Eval_Id</th>
<th>Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>e1</td>
<td>Hermione Grainger</td>
</tr>
<tr>
<td>e2</td>
<td>Draco Malfoy</td>
</tr>
<tr>
<td>e3</td>
<td>Harry Potter</td>
</tr>
<tr>
<td>e4</td>
<td>Ron Weasley</td>
</tr>
</tbody>
</table>
Details of the Conversion

- Create an entity in the new *Evaluation* entity set for each instance (row) in the ternary *Evaluation* relationship.
- In the *Student_of* relationship, relate each entity in the *Evaluation* entity set with the corresponding student entity.
- How many students can the *Student_of* relationship relate an *Evaluation* entity to?

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Students
Courses
Evaluation
Professors

Student−of
Professor−of
Course−of
Eval_id

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Details of the Conversion

- Create an entity in the new Evaluation entity set for each instance (row) in the ternary Evaluation relationship.
- In the Student_of relationship, relate each entity in the Evaluation entity set with the corresponding student entity.
- How many students can the Student_of relationship relate an Evaluation entity to? Only one!
- Therefore, the multiplicity of Student_of is many-to-one from Evaluation to Student.
Subclasses in the E/R Model

- A *subclass* of an entity set $E$ is an entity set $F$ such that
  - each entity in $F$ is an entity in $E$.
  - the entity set $F$ must have at least one attribute or participate in at least one relationship that $E$ does not.

- Connect $E$ to $F$ using an *isa* relationship denoted by a triangle.
- Convention is to draw $E$ above $F$.
- Each *isa* relationship is one-one but we do not draw the arrows.
- The set of *isa* relationships must form a tree.
Example of Subclasses

- University Employees, Handout 2.
Example of Subclasses

- University Students, Handout 2 (ignore underlines, double shapes).
E/R vs. OO Subclasses

- In object-oriented programming languages, each object is in only one class.
  - A subclass inherits variables and methods from the superclasses.
- In an E/R diagram, an entity has components in all the subclasses to which it belongs.
  - If an entity $e$ has a component in an subclass, then $e$ has a component in the superclass.
    - Does $e$ have a component in the root?
  - The attributes of $e$ are the union of the attributes of its components.
  - $e$ participates in all the relationships its components participate in.
Prof. Fingers InMany Pies has a 9-month appointment, teaches in one semester every year, and does not teach in the other semester. In the other semester, his research grant pays his salary. Which entity sets does he have components in? (using a different isa hierarchy)
Components of an Entity

How do we represent students enrolled in combined Bachelors-Masters programmes?
Components of an Entity

- How do we represent students enrolled in combined Bachelors-Masters programmes?
- Such a student has components in multiple entity sets.