Chapter 2
Conceptual Modeling

Towards More Complex
Entity Relationship Diagrams

Objectives

• Model different types of attributes, entities, relationships, and cardinalities
  – Strong vs. Weak Entities
  – Relationships with Attributes
  – Unary and Ternary Relationships
  – Multiple Relationships
• Draw E-R diagrams for common business situations
• Convert M:M relationships to associative entities
• Model time-dependent data using time stamps
Strong vs. Weak Entities

- **Strong entity**
  - Exists independently of other types of entities
  - Has its own unique identifier
  - Identifier underlined with single-line

- **Weak entity**
  - Dependent on a strong entity ... cannot exist on its own
  - Does not have a unique identifier (only a partial identifier)
  - Partial identifier underlined with double-line
  - Entity box has double line

- **Identifying relationship**
  - links strong entities to weak entities

Figure 2-5 Example of a weak identity and its identifying relationship
Practice: Course Sections

- Model the courses using two entities: COURSE and SECTION.
- Each course has a number and a title, and may have zero or more sections.
- Each section has a number and the term offered, which is composed of semester and year.
Practice: Weak Entities

• Give another example of a weak entity type.

Relationships with Attributes
Figure 2-11a A binary relationship with an attribute
Attribute on a relationship (Link Attribute/Associative)

Here, the date completed attribute pertains specifically to the employee’s completion of a course…it is an attribute of the relationship
Practice: Relationships with Attributes

• #10, page 103. The figure below shows a grade report that is mailed to students at the end of each semester.

Prepare an ERD reflecting the data contained in the grade report. Assume that each course is taught by one instructor.

<table>
<thead>
<tr>
<th>NAME:</th>
<th>Emily Williams</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAMPUS ADDRESS:</td>
<td>208 Brooks Hall</td>
</tr>
<tr>
<td>MAJOR:</td>
<td>Information Systems</td>
</tr>
<tr>
<td>ID:</td>
<td>268300458</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COURSE ID</th>
<th>TITLE</th>
<th>INSTRUCTOR NAME</th>
<th>INSTRUCTOR LOCATION</th>
<th>GRADE</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 350</td>
<td>Database Mgt.</td>
<td>Codd</td>
<td>B104</td>
<td>A</td>
</tr>
<tr>
<td>IS 465</td>
<td>System Analysis</td>
<td>Parsons</td>
<td>B317</td>
<td>B</td>
</tr>
</tbody>
</table>
Example (revisited): Consider \textit{DependentDate} (similar to \textit{CompletedDate}) for when \textit{DEPENDENT} begins to be carried by \textit{EMPLOYEE}. \textbf{Could you associate it with relationship Carries?}

\begin{center}
\includegraphics[width=\textwidth]{diagram}
\end{center}

\textbf{Review}

- Strong entity
- Weak entity
- Relationship without attributes
- Relationship with attributes
Relevant Textbook Exercises

- Exercise #2 (f), page 102
- Exercise #17(a,g,h), pages 104-105
- Exercise #19, page 105
- Exercise #27, page #107

Associative Entities
Associative Entities

• One of the hardest concepts in E-R modeling

• *An associative entity is a relationship transformed into an entity*

• Each *instance* of an associative entity represents an *instance* of the relationship

• Needed to represent ternary relationships, and for cases when we need to convert a relationship into an entity, to relate it to other entities.

Associative Entities - Example

• Previous model: a database of courses taken by employees. For each employee we keep its SSN (identifier), name and birth date, and for each course we keep its id and title. We also keep the date the employee completed that course.

• Suppose that we also want to record information about the institutions issuing the certificates. *HOW???*
Figure 2-11b An associative entity (CERTIFICATE)

Associative entity is like a relationship with an attribute, but it is also considered to be an entity in its own right

Note that the many-to-many cardinality between entities in Figure 2-11a has been replaced by two one-to-many relationships with the associative entity.
Fill in the missing cardinalities.
What is an alternative to assign the PK?

**Associative Entities**

- An **entity** - has attributes
- A **relationship** - links entities together
- When should a *relationship with attributes* instead be an **associative entity**?
  - All relationships for the associative entity should be many
  - The associative entity could have meaning independent of the other entities
  - The associative entity preferably has a unique identifier, and should also have other attributes
  - The associative entity may participate in other relationships other than the entities of the associated relationship
Exercise 9, page 103

Visio does not explicitly show associative entities. Find them.

Ternary Relationships
Ternary Relationships

- Relationships of degree 3
- Associates three entities \textit{at the same time}
- Can't we just live with binary relationships?

Ternary Relationship - Example

- Say we wanted to keep track of which Person got which Degrees from which University.

- Can this be modeled with binary relationships?
• Person p1 got degree d1 from university u2
• Person p3 got degree d1 from university u4
• Person p3 got degree d3 from university u4
• Person p4 got degree d3 from university u1

• p1 gets degree d1 from … u2 or u4?
• p3 gets degree d1 from … u2 or u4?
Ternary Relationship - Example

• Yes, with the help of an associative entity

![Diagram](PERSON -- DIPLOMA -- UNIVERSITY)

• Ternary relationship “got” is now an associative entity, DIPLOMA. **Cardinality constraints?**

Example – Cardinalities Constraints

![Diagram](PERSON -- DIPLOMA -- UNIVERSITY)

As a general rule, ternary relationships should be converted to associative entities.
• p1 got d1 from u2
• p3 got d1 from u4
• p3 got d3 from u4
• p4 got d3 from u1

Figure 2-12 Example of a ternary relationship

Note: a relationship can have attributes of its own
Fig. 2-14: Ternary relationships as an associative entity

Fig. 2-18: Cardinality constraints in a ternary relationship

Each vendor can supply many parts to any number of warehouses, but need not supply any parts.

Each part can be supplied by any number of vendors to more than one WH, but each part must supplied by at least one vendor to a WH.

Each WH can be supplied with any number of parts from more than one vendor, but each WH must be supplied with at least one part.
Practice: Ternary Relationships

• Give another example of a ternary relationship.
Practice: Ternary Relationships

Exercise #20, page #106.

• Each semester, each student must be assigned an adviser who counsels students about degree requirements and helps students register for classes.

• Each student must register for classes with the help of an adviser, but if the student’s assigned adviser is not available, the student may register with any adviser.

• We must keep track of students, the assigned adviser for each, and the name of the adviser with whom the student registered for the current term.

• Represent this situation of students and advisers with an E-R diagram.
Relevant Textbook Exercises

- Exercise #17(b), page 104
- Exercise #23, page 106

Unary Relationships
Unary Relationships

• Relationships of degree 1
• Also known as recursive relationships
• Two or more entities in the relationship are of the same type
• Example: we want to represent when an employee supervises another employee.

Example: Supervises

• Example: we want to represent when an employee supervises another employee.
• We could start with something like this:
Example: Supervises

- But supervisors can have their own supervisors
- Both supervisor and supervisee are employees, so we need a recursive relationship, with roles

And, of course, add cardinalities
- Should always define roles – even more important when cardinalities are different
• Two roles:
  supervisor (1) and supervisee (2)

Fig. 2-12 (a) Unary relationships

Practice: Add missing cardinalities.
A person is married to at most one other person, or may not be married at all.

**Example: Bill Of Materials**

- Part-Whole is also a recursive relationship:
This could just be a relationship with attributes…it’s a judgment call
Two roles: part (1) and whole (2)

Practice: Unary Relationships

• Give another example of a unary relationship.
Practice: Unary Relationships

Draw an E/R diagram for the following variations:

1. All we need to know is who a person is currently married to, if any
2. We need to know who a person has ever been married to
3. Same as 2, but we also need to know the marriage date and dissolution date
4. Same as 3, but assume that same 2 people can remarry
Relevant Textbook Exercises

- Exercise #2(d, g), page 102

Attributes or Entity?

- Sometimes you will wonder whether to represent data as an attribute or an entity. This is a common dilemma.
- Let us look at a few situations.
Attributes or Entity?

- So when **SHOULD** an attribute be linked to an entity type via a relationship?
  - Attribute refers to a concept in the data model
  - Multiple entity instances share the same attribute
- Example on next page
Multiple Relationships

• More than one relationship between the same entity types (Fig. 2-21)
Fig. 2-21: Examples of multiple relationships
(a) Employees and departments

Entities can be related to one another in more than one way.

Fig. 2-21: (b) Professors and courses (fixed upon constraint)

A New Business Rule:
An instructor who is scheduled to teach a course must be qualified to teach that course?

Here, minimum cardinality constraint is 2, what’s for?
At least two professors must be qualified to teach each course.
Each professor must be qualified to teach at least one course.
Practice: Multiple Relationships

• Exercise #17(d), page #104.

A hospital has a large number of registered physicians. Attributes of PHYSICIAN include Physician ID (the identifier) and Specialty. Patients are admitted to the hospital by physicians. Attributes of PATIENT include Patient ID (the identifier) and Patient Name. Any patient who is admitted must have exactly one admitting physician. A physician may optionally admit any number of patients. Once admitted, a given patient must be treated by at least one physician. A particular physician may treat any number of patients, or may not treat any patients. Whenever a patient is treated by a physician, the hospital wishes to record the details of the treatment (Treatment Detail). Components of Treatment Detail include Date, Time, and Results.

Does your ERD allow for the same patient to be admitted by different physicians over time? How would you include on the ERD the need to represent the date on which a patient is admitted for each time they are admitted?
Practice: Multiple Relationships

- Exercise #17(i), page #105.

Each publisher has a unique name; a mailing address and telephone number are also kept on each publisher. A publisher publishes one or more books; a book is published by exactly one publisher. A book is identified by its ISBN, and other attributes are title, price, and number of pages. Each book is written by one or more authors; an author writes one or more books, potentially for different publishers. Each author is uniquely described by an author ID, and we know each author’s name and address. Each author is paid a certain royalty rate on each book he or she authors, which potentially varies for each book and for each author. An author receives a separate royalty check for each book he or she writes. Each check is identified by its check number, and we also keep track of the date and amount of each check.
Relevant Textbook Exercises

- Exercises #13, #15, page 103
- Exercise #22, page 106
- Exercises #25, #26, #28, page 107
- Exercise #29, page 108

Modeling Time-Dependent Data

Figure 2-19. Simple example of time-stamping

This attribute is both multivalued and composite.
Fig. 2-20: (a) E-R diagram **not** recognizing product assignment

Fig. 2-20: (b) E-R diagram **recognizing** product assignment

- Reassignment
Fig. 2-20: (a) E-R diagram not recognizing product reassignment

In the middle of year, due to a reorganization of the sales function some products are reassigned to different product lines

<table>
<thead>
<tr>
<th>Sales</th>
<th>Product</th>
<th>Product-Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>$50,000</td>
<td>P</td>
<td>B</td>
</tr>
<tr>
<td>$40,000</td>
<td>P</td>
<td>A</td>
</tr>
</tbody>
</table>

(out of $50,000)

Fig. 2-20: Pine Valley Furniture product database

Solution: adding a new relationship of “Sales_for_product_line”

(b) E-R diagram recognizing product reassignment
Fig. 2-20: Pine Valley Furniture product database
(c) E-R diagram with associative entity for product assignment to product line over time

The Entity Relationship (E-R) Model

Congratulations !!
You have just learned one of the most important modeling concept (E-R) for developing the database systems.
Recognizing Different ERD Notations

Different modeling software tools may have different notation for the same constructs.
Fig. 2-22: E-R diagram for Pine Valley Furniture Company