Chapter 3: Modeling Data in the Organization

Modern Database Management
7th Edition

Jeffrey A. Hoffer, Mary B. Prescott, Fred R. McFadden
SDLC Revisited – Data Modeling is an Analysis Activity (figures 2-4, 2-5)

Purpose – thorough analysis
Deliverable – functional system specifications

Database activity – conceptual data modeling

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Simpelt E-R diagram

Lavet i Omnigraffle, som man selv gratis kan installere på Mac. ITU Maclab er i 2A54.
Sample E-R Diagram (Figure 3-1)

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Relationship symbols

Entity symbols

A special entity that is also a relationship

Attribute symbols

Relationship cardinalities specify how many of each entity type is allowed

Relationship degrees specify number of entity types involved
What Should an Entity Be?

- **SHOULD BE:**
  - An object that will have many instances in the database
  - An object that will be composed of multiple attributes
  - An object that we are trying to model

- **SHOULD NOT BE:**
  - A user of the database system
  - An output of the database system (e.g. a report)
Figure 3-4

Inappropriate entities

TREASURER

Manages

ACCOUNT

Receives

is_charged

EXPENSE REPORT

Summarizes

EXPENSE

System user

System output

ACCOUNT

is_charged

EXPENSE

Appropriate entities

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Problemsession (5-10 min)

- Vi vil designe en database til en lille butik med information om kunderne, order og kredit:
  - Navne og adresser
  - Telefonnumre
  - Kundetyper (privat eller forretning)
  - Aktuelle ordrer
  - Kundenumre
  - Maximum kredit
  - Aktuel kredit

Tegn et muligt E-R diagram for databasen.
More on Relationships

- Relationship Types vs. Relationship Instances
  - The relationship type is modeled as the diamond and lines between entity types...the instance is between specific entity instances

- Relationships can have attributes
  - These describe features pertaining to the association between the entities in the relationship

- Two entities can have more than one type of relationship between them (multiple relationships)

- Associative Entity – combination of relationship and entity
Figure 3-10a  Relationship type and instances - Relationship type (Completes)

Employee_ID  Employee_Name  Birth_Date  Course_ID  Course_Title  Topic

EMPLOYEE  Complements  COURSE

Figure 3-10b  Relationship type and instances - Relationship instances

Employee  Course
Chen  C++
Melton  Java
Ritchie  COBOL
Celko  Visual Basic
Gosling  Perl

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Degree of Relationships

- Degree of a relationship is the number of entity types that participate in it
  - Unary Relationship
  - Binary Relationship
  - Ternary Relationship
Degree of relationships – from Figure 3-2

- One entity related to another of the same entity type
- Entities of two different types related to each other
- Entities of three different types related to each other
Cardinality of Relationships

- **One-to-One**
  - Each entity in the relationship will have exactly one related entity

- **One-to-Many**
  - An entity on one side of the relationship can have many related entities, but an entity on the other side will have a maximum of one related entity

- **Many-to-Many**
  - Entities on both sides of the relationship can have many related entities on the other side
Cardinality Constraints

- Cardinality Constraints - the number of instances of one entity that can or must be associated with each instance of another entity

- Minimum Cardinality
  - If zero, then optional
  - If one or more, then mandatory

- Maximum Cardinality
  - The maximum number
Figure 3-12a  Examples of relationships of different degrees - Unary relationships

- PERSON and Is_married_to
  - One-to-one

- EMPLOYEE and Manages
  - One-to-many

- TEAM and Stands
  - One-to-one
Figure 3-12b  Examples of relationships of different degrees - Binary relationships

- EMPLOYEE Is_assigned PARKING PLACE: One-to-one
- PRODUCT LINE Contains PRODUCT: One-to-many
- STUDENT Registers_for COURSE: Many-to-many
Basic relationship with only maximum cardinalities showing – Figure 3-16a

![Diagram of MOVIE and VIDEOTAPE with the relationship Is_stocked_as](image)

Mandatory minimum cardinalities – Figure 3-17a

![Diagram of PATIENT, Has, and PATIENT HISTORY with examples of visits](image)
Figure 3-17c
Optional cardinalities with unary degree, one-to-one relationship

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Figure 3-11a A binary relationship with an attribute

Here, the date completed attribute pertains specifically to the employee’s completion of a course…it is an attribute of the relationship
Figure 3-12c -- A ternary relationship with attributes

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Figure 3-13a – A unary relationship with an attribute. This has a many-to-many relationship.

Representing a bill-of-materials structure
Figure 3-13b  Representing a bill-of-materials structure -
Two ITEM bill-of-materials structure instances

<table>
<thead>
<tr>
<th>Mountain Bike MX300</th>
<th>Tandem Bike TR425</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handle Bars HX100 Qty: 1</td>
<td>Handle Bars HT200 Qty: 2</td>
</tr>
<tr>
<td>Transmission System TX100 Qty: 1</td>
<td>Transmission System TX101</td>
</tr>
<tr>
<td>Wheels WX240 Qty: 2</td>
<td>Wheels WX240 Qty: 2</td>
</tr>
<tr>
<td>Brakes BR450 Qty: 2</td>
<td>Brakes BR250 Qty: 2</td>
</tr>
<tr>
<td>Derailer DX500 Qty: 1</td>
<td>Derailer DX500 Qty: 1</td>
</tr>
<tr>
<td>Wheel Trim WT100 Qty: 2</td>
<td>Wheel Trim WT100 Qty: 2</td>
</tr>
</tbody>
</table>
Figure 3-21a Examples of multiple relationships - Employees and departments

Entities can be related to one another in more than one way
Figure 3-21b  Examples of multiple relationships - Professors and courses (fixed upper limit constraint)

Here, max cardinality constraint is 4
E-R diagram til problemsession

![E-R diagram](image)
Attributes

- Attribute - property or characteristic of an entity type

- Classifications of attributes:
  - Required versus Optional Attributes
  - Simple versus Composite Attribute
  - Single-Valued versus Multivalued Attribute
  - Stored versus Derived Attributes
  - Identifier Attributes
Identifiers (Keys)

- Identifier (Key) - An attribute (or combination of attributes) that uniquely identifies individual instances of an entity type
- Simple Key versus Composite Key
- Candidate Key – an attribute that could be a key...satisfies the requirements for being a key
Characteristics of Identifiers

- Will not change in value
- Will not be null
- No intelligent identifiers (e.g. containing locations or people that might change)
- Substitute new, simple keys for long, composite keys
Figure 3-7 – A **composite** attribute

An attribute broken into component parts

- Street_Address
- City
- State
- Postal_Code
Figure 3-9a – Simple key attribute

The key is underlined

Student_ID

Student_Name

Other_Attributes

STUDENT
Figure 3-9b – Composite key attribute

The key is composed of two subparts

Flight_Number → Flight_ID → Date → Number_of_Passengers

Flight_ID

Date

Number_of_Passengers

FLIGHT
Figure 3-8 – Entity with a multivalued attribute (Skill) and derived attribute (Years_Employed)

What’s wrong with this?

**Derived**
from date employed and current date

**Multivalued:**
an employee can have more than one skill
Figure 3-19 – An attribute that is both multivalued and composite

This is an example of time-stamping
Multivalued attributes can be represented as relationships

Figure 3-15a Using relationships to link related attributes - Multivalued attribute versus relationships via bill-of-materials structure

Figure 3-15b Using relationships to link related attributes - Composite, multivalued attribute versus relationship
Strong vs. Weak Entities, and Identifying Relationships

- **Strong entities**
  - exist independently of other types of entities
  - has its own unique identifier
  - represented with single-line rectangle

- **Weak entity**
  - dependent on a strong entity...cannot exist on its own
  - does not have a unique identifier
  - represented with double-line rectangle

- **Identifying relationship**
  - links strong entities to weak entities
  - represented with double line diamond
Figure 3-5a  Example of a weak entity and its identifying relationship - E-R notation

Strong entity  Identifying relationship  Weak entity
Associative Entities

- It’s an **entity** – it has attributes
- AND it’s a **relationship** – it 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
  - Ternary relationships should be converted to associative entities

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Figure 3-11b – An associative entity (CERTIFICATE)

Associative entity involves a rectangle with a diamond inside. Note that the many-to-many cardinality symbols face toward the associative entity and not toward the other entities.
Figure 3-13c – An associative entity – bill of materials structure

This could just be a relationship with attributes…it’s a judgment call
Figure 3-18 – Ternary relationship as an associative entity