Chapter 4 Entity Relationship Modeling

In this chapter, you will learn:

• What a conceptual model is and what its purpose is
• The difference between internal and external models
• How internal and external models serve the database design process
• How relationships between entities are defined and refined, and how such relationships are incorporated into the database design process
• How ERD components affect database design and implementation
• How to interpret the modeling symbols for the four most popular E-R modeling tools
• That real-world database design often requires you to reconcile conflicting goals
Basic Modeling Concepts

• Art and science
• Good judgment coupled with powerful design tools
• Models
  – “Description or analogy used to visualize something that cannot be directly observed” Webster’s Dictionary
• Data Model
  – Relatively simple representation of complex real-world data structures
Data Models: Degrees of Data Abstraction

Figure 3.1

- **Conceptual model**
  - High: Hardware-independent, Software-independent
  - Medium: Hardware-independent, Software-dependent
  - Low: Hardware-dependent, Software-dependent

- **External model**
- **Internal model**
- **Physical model**

DBMS:
- Relational
- Hierarchical

Chapter 4 Entity Relationship (E-R) Modeling
Degrees of Abstraction

• Conceptual
  – Global view of data
  – Basis for identification and description of main data items
  – ERD used to represent conceptual data model
  – Hardware and software independent

• Internal
  – Representation of database as seen by DBMS
  – Adapts conceptual model to specific DBMS
  – Software dependent
Degrees of Abstraction (con’t.)

• External
  – Users’ views of data environment
  – Provides subsets of internal view
  – Makes application program development easier
  – Facilitates designers’ tasks
  – Ensures adequacy of conceptual model
  – Ensures security constraints in design

• Physical
  – Lowest level of abstraction
  – Software and hardware dependent
  – Requires definition of physical storage devices and access methods
The Entity Relationship (E-R) Model

- Represents conceptual view
- Main Components
  - Entities
    - Corresponds to entire table, not row
    - Represented by rectangle
  - Attributes
    - Characteristics of entities
    - Domain is set of possible values
    - Primary keys underlined
  - Relationships
Attributes (con’t.)

- **Simple**
  - Cannot be subdivided
  - Age, sex, marital status
- **Composite**
  - Can be subdivided into additional attributes
  - Address into street, city, zip
- **Single-valued**
  - Can have only a single value
  - Person has one social security number
- **Multi-valued**
  - Can have many values
  - Person may have several college degrees
- **Derived**
  - Can be derived with algorithm
  - Age can be derived from date of birth
Relationships

• Association between entities
• Connected entities are called participants
• Operate in both directions
• Connectivity describes relationship classification
  – 1:1, 1:M, M:N
• Cardinality
  – Expresses number of entity occurrences associated with one occurrence of related entity
Connectivity and Cardinality in an ERD

Figure 3.12
Relationship Strength

- **Existence dependence**
  - Entity’s existence depends on existence of related entities
  - Existence-independent entities can exist apart from related entities
  - EMPLOYEE claims DEPENDENT

- **Weak (non-identifying)**
  - One entity is existence-independent on another
  - PK of related entity doesn’t contain PK component of parent entity

- **Strong (identifying)**
  - One entity is existence-dependent on another
  - PK of related entity contains PK component of parent entity
Relationship Participation

- **Optional**
  - Entity occurrence does not require a corresponding occurrence in related entity
  - Shown by drawing a small circle on side of optional entity on ERD
- **Mandatory**
  - Entity occurrence requires corresponding occurrence in related entity
  - If no optionality symbol is shown on ERD, it is mandatory
Weak Entity

- Existence-dependent on another entity
- Has primary key that is partially or totally derived from parent entity
Relationship Degree

- Indicates number of associated entities
- Unary Single entity
  - Recursive
  - Exists between occurrences of same entity set
- Binary
  - Two entities associated
- Ternary
  - Three entities associated
Composite Entities

- Used to ‘bridge’ between M:N relationships
- Bridge entities composed of primary keys of each entity needing connection

![Chen model](image)

![Crow’s Foot model](image)

Figure 3.30

Figure 3.31
Entity Supertypes and Subtypes

• Generalization hierarchy
  – Depicts relationships between higher-level supertype and lower-level subtype entities
  – Supertype has shared attributes
  – Subtypes have unique attributes
  – Disjoint relationships
    • Unique subtypes
    • Non-overlapping
    • Indicated with a ‘G’
  – Overlapping subtypes use ‘Gs’ Symbol
Generalization Hierarchy with Overlapping Subtypes

Figure 3.35
Comparison of E-R Modeling Symbols

• Alternate styles developed to enable easier use of CASE tools
• Chen
  – Move conceptual design into practical database design arena
• Crow’s Foot
  – Cannot detail all cardinalities
• Rein85
  – Similar to Crow’s Foot
  – Operates at higher level of abstraction
• IDEF1X
  – Derivative of ICAM studies in the late 1970’s
  – Uses fewer symbols
## Comparison of E-R Modeling Symbols

<table>
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<tr>
<th></th>
<th>Chen</th>
<th>Crow’s Foot</th>
<th>Rein85</th>
<th>IDEF1X</th>
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<tr>
<td><strong>Many (M) symbol</strong></td>
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<tr>
<td><strong>Weak entity</strong></td>
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![Figure 3.36](image)

Chapter 4  Entity Relationship (E-R) Modeling
Developing an E-R Diagram

• Iterative Process
  – Step1: General narrative of organizational operations developed
  – Step2: Basic E-R Model graphically depicted and reviewed
  – Step3: Modifications made to incorporate newly discovered E-R components

• Repeat process until designers and users agree E-R Diagram complete
Supertype/Subtype Relationship in an ERD

Figure 3.42
First ERD Segment Established

Figure 3.43
Second and Third ERD Segments Established

Figures 3.44 & 3.45
Fourth and Fifth ERD Segments Established

Figures 3.46 & 3.47
Sixth and Seventh ERD Segments Established

Figures 3.48 & 3.49
Eighth ERD Segment Established

Figures 3.50
Ninth ERD Segment Established

Figures 3.51
### Components of E-R Model

<table>
<thead>
<tr>
<th>ENTITY</th>
<th>RELATIONSHIP</th>
<th>CONNECTIVITY</th>
<th>ENTITY</th>
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<td>DEPARTMENT</td>
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<td>CLASS</td>
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</table>

Table 3.2
Completed ERD

Figure 3.52
Challenge of Database Design: Conflicting Goals

- Database must be designed to conform to design standards
- High-speed processing may require design compromises
- Quest for timely information may be the focus of database design
- Other concerns
  - Security
  - Performance
  - Shared access
  - Integrity