Chapter 9
Relational Database Design by ER- and EER-to-Relational Mapping
Chapter 9 Outline

- Relational Database Design Using ER-to-Relational Mapping
- Mapping EER Model Constructs to Relations
Relational Database Design by ER- and EER-to-Relational Mapping

- Design a relational database schema
  - Based on a conceptual schema design
- Seven-step algorithm to convert the basic ER model constructs into relations
- Additional steps for EER model
Relational Database Design Using ER-to-Relational Mapping

Figure 9.1
The ER conceptual schema diagram for the COMPANY database.

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Figure 9.2
Result of mapping the COMPANY ER schema into a relational database schema.
ER-to-Relational Mapping Algorithm

- COMPANY database example
  - Assume that the mapping will create tables with simple single-valued attributes

- Step 1: Mapping of Regular Entity Types
  - For each regular entity type, create a relation $R$ that includes all the simple attributes of $E$
  - Called entity relations
    - Each tuple represents an entity instance
ER-to-Relational Mapping Algorithm (cont’d.)

- Step 2: Mapping of Weak Entity Types
  - For each weak entity type, create a relation $R$ and include all simple attributes of the entity type as attributes of $R$
  - Include primary key attribute of owner as foreign key attributes of $R$
Figure 9.3
Illustration of some mapping steps.
a. Entity relations after step 1.
b. Additional weak entity relation after step 2.
c. Relationship relation after step 5.

(a) EMPLOYEE
    Fname  Minit  Lname  Sex  Bdate  Address  Sex  Salary

DEPARTMENT
    Dname  Dnumber

PROJECT
    Pname  Pnumber  Plocation

(b) DEPENDENT
    Essn  Dependent_name  Sex  Bdate  Relationship

(c) WORKS_ON
    Essn  Pho  Hours

(d) DEPT_LOCATIONS
    Dnumber  Dlocation
Step 3: Mapping of Binary 1:1 Relationship Types

- For each binary 1:1 relationship type
  - Identify relations that correspond to entity types participating in $R$

Possible approaches:
- Foreign key approach
- Merged relationship approach
- Crossreference or relationship relation approach
ER-to-Relational Mapping Algorithm (cont’d.)

- Step 4: Mapping of Binary 1:\(N\) Relationship Types
  - For each regular binary 1:\(N\) relationship type
    - Identify relation that represents participating entity type at \(N\)-side of relationship type
    - Include primary key of other entity type as foreign key in \(S\)
    - Include simple attributes of 1:\(N\) relationship type as attributes of \(S\)
ER-to-Relational Mapping Algorithm (cont’d.)

- Alternative approach
  - Use the *relationship relation* (cross-reference) option as in the third option for binary 1:1 relationships
ER-to-Relational Mapping Algorithm (cont’d.)

- **Step 5: Mapping of Binary $M:N$ Relationship Types**
  - For each binary $M:N$ relationship type
    - Create a new relation $S$
    - Include primary key of participating entity types as foreign key attributes in $S$
    - Include any simple attributes of $M:N$ relationship type
ER-to-Relational Mapping Algorithm (cont’d.)

- Step 6: Mapping of Multivalued Attributes
  - For each multivalued attribute
    - Create a new relation
    - Primary key of $R$ is the combination of $A$ and $K$
    - If the multivalued attribute is composite, include its simple components
ER-to-Relational Mapping Algorithm (cont’d.)

- **Step 7: Mapping of $N$-ary Relationship Types**
  - For each $n$-ary relationship type $R$
    - Create a new relation $S$ to represent $R$
    - Include primary keys of participating entity types as foreign keys
    - Include any simple attributes as attributes
## Discussion and Summary of Mapping for ER Model Constructs

### Table 9.1: Correspondence between ER and Relational Models

<table>
<thead>
<tr>
<th>ER MODEL</th>
<th>RELATIONAL MODEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entity type</td>
<td><em>Entity</em> relation</td>
</tr>
<tr>
<td>1:1 or 1:N relationship type</td>
<td>Foreign key (or <em>relationship</em> relation)</td>
</tr>
<tr>
<td>M:N relationship type</td>
<td><em>Relationship</em> relation and <em>two</em> foreign keys</td>
</tr>
<tr>
<td><em>n</em>-ary relationship type</td>
<td><em>Relationship</em> relation and <em>n</em> foreign keys</td>
</tr>
<tr>
<td>Simple attribute</td>
<td><em>Attribute</em></td>
</tr>
<tr>
<td>Composite attribute</td>
<td>Set of simple component attributes</td>
</tr>
<tr>
<td>Multivalued attribute</td>
<td><em>Relation</em> and foreign key</td>
</tr>
<tr>
<td>Value set</td>
<td><em>Domain</em></td>
</tr>
<tr>
<td>Key attribute</td>
<td>Primary (or secondary) key</td>
</tr>
</tbody>
</table>
In a relational schema relationship, types are not represented explicitly
- Represented by having two attributes $A$ and $B$: one a primary key and the other a foreign key
Mapping EER Model Constructs to Relations

- Extending ER-to-relational mapping algorithm
Mapping of Specialization or Generalization

- Step 8: Options for Mapping Specialization or Generalization (see pages 294-295)
  - Option 8A: Multiple relations—superclass and subclasses
    - For any specialization (total or partial, disjoint or overlapping)
  - Option 8B: Multiple relations—subclass relations only
    - Subclasses are total
    - Specialization has disjointedness constraint
Mapping of Specialization or Generalization (cont’d.)

- **Option 8C: Single relation with one type attribute**
  - Type or discriminating attribute indicates subclass of tuple
  - Subclasses are disjoint
    - Potential for generating many NULL values if many specific attributes exist in the subclasses

- **Option 8D: Single relation with multiple type attributes**
  - Subclasses are overlapping
  - Will also work for a disjoint specialization
Mapping of Shared Subclasses (Multiple Inheritance)

- Apply any of the options discussed in step 8 to a shared subclass

Figure 9.6
Mapping the EER specialization lattice in Figure 8.8 using multiple options.
Mapping of Categories (Union Types)

- Step 9: Mapping of Union Types (Categories)
  - Defining superclasses have different keys
  - Specify a new key attribute
    - Surrogate key
Figure 9.7
Mapping the EER categories (union types) in Figure 8.8 to relations.

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PERSON
- Ssn
- Driver_license_no
- Name
- Address
- Owner_id

BANK
- Bname
- Baddress
- Owner_id

COMPANY
- Cname
- Caddress
- Owner_id

OWNER
- Owner_id

REGISTERED_VEHICLE
- Vehicle_id
- License_plate_number

CAR
- Vehicle_id
- Cstyle
- Cmake
- Cmodel
- Cyear

TRUCK
- Vehicle_id
- Tmake
- Tmodel
- Tonnage
- Tyear

OWNS
- Owner_id
- Vehicle_id
- Purchase_date
- Lien_or_regular
Summary

- Map conceptual schema design in the ER model to a relational database schema
  - Algorithm for ER-to-relational mapping
  - Illustrated by examples from the COMPANY database
- Include additional steps in the algorithm for mapping constructs from EER model into relational model