Fundamentals of DATABASE SYSTEMS FOURTH EDITION

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Chapter 7

Relational Database Design by ER- and EER-to-Relational Mapping



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Chapter Outline

ER-to-Relational Mapping Algorithm

Step 1: Mapping of Regular Entity Types
Step 2: Mapping of Weak Entity Types
Step 3: Mapping of Binary 1:1 Relation Types
Step 4: Mapping of Binary 1:N Relationship Types.
Step 5: Mapping of Binary M:N Relationship Types.
Step 6: Mapping of Multivalued attributes.
Step 7: Mapping of N-ary Relationship Types.

Mapping EER Model Constructs to Relations

Step 8: Options for Mapping Specialization or Generalization. Step 9: Mapping of Union Types (Categories).

• Step 1: Mapping of Regular Entity Types.

- For each regular (strong) entity type E in the ER schema,
 - create a relation R that includes all the simple attributes of E.
- Choose one of the key attributes of E as the primary key for R.
- If the chosen key of E is composite, the set of simple attributes that form it will together form the primary key of R.

Example:

For relations EMPLOYEE, DEPARTMENT, and PROJECT in the relational schema = regular entities in the ER diagram.

SSN, DNUMBER, and PNUMBER are the primary keys for the relations EMPLOYEE, DEPARTMENT, and PROJECT as shown.

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• Step 2: Mapping of Weak Entity Types

- For each weak entity type W in the ER schema with owner entity type E,
 - create a relation R and include all simple attributes (or simple components of composite attributes) of W as attributes of R.
- In addition, include as foreign key attributes of R the primary key attribute(s) of the relation(s) that correspond to the owner entity type(s).
- The primary key of R is the *combination of* the primary key(s) of the owner(s) and the partial key of the weak entity type W, if any.

- Step 2: Mapping of Weak Entity Types
 - Example:
 - •For the weak entity type DEPENDENT, include the primary key SSN of the EMPLOYEE relation as a foreign key attribute of DEPENDENT (renamed to ESSN).
 - The primary key of the DEPENDENT relation is the combination {ESSN, DEPENDENT_NAME} because
 DEPENDENT_NAME is the partial key of DEPENDENT.



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Step 3: Mapping of Binary 1:1 Relation Types

For each binary 1:1 relationship type R in the ER schema, identify the relations S and T that correspond to the entity types participating in R. There are three possible approaches:

(1) Foreign Key approach:

Choose one of the relations-S, say-and include a foreign key in S the primary key of T. It is better to choose an entity type with *total participation* in R in the role of S.

Example:

1:1 relation MANAGES is mapped by choosing the participating entity type DEPARTMENT to serve in the role of S, because its participation in the MANAGES relationship type is total. Chapter 7-9

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Step 3: Mapping of Binary 1:1 Relation Types

(2) Merged relation option:

An alternate mapping of a 1:1 relationship type is possible by merging the two entity types and the relationship into a single relation.

This may be appropriate when *both participations are total*.

(3) **Cross-reference or relationship relation option:**

The third alternative is to set up a third relation R for the purpose of crossreferencing the primary keys of the two relations S and T representing the entity types.

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• Step 4: Mapping of Binary 1:N Relationship Types.

- For each regular binary 1:N relationship type R, identify the relation S that represent the participating entity type at the N-side of the relationship type.
- Include as foreign key in S the primary key of the relation T that represents the other entity type participating in R.
- Include any simple attributes of the 1:N relation type as attributes of S.

Example:

1:N relationship types WORKS_FOR, CONTROLS, and SUPERVISION in the figure.

For WORKS_FOR, include the primary key DNUMBER of the DEPARTMENT relation as foreign key in the EMPLOYEE relation and call it DNO.



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• Step 5: Mapping of Binary M:N Relationship Types.

- For each regular binary M:N relationship type R,

• create a new relation S to represent R.

- Include as foreign key attributes in S the primary keys of the relations that represent the participating entity types; *their combination will form the primary key* of S.
- Also include any simple attributes of the M:N relationship
 type (or simple components of composite attributes) as
 attributes of S.

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• Step 5: Mapping of Binary M:N Relationship Types.

- Example:

The M:N relationship type WORKS_ON from the ER diagram is mapped by creating a relation WORKS_ON in the relational database schema. The primary keys of the PROJECT and EMPLOYEE relations are included as foreign keys in WORKS_ON and renamed PNO and ESSN, respectively.

Attribute HOURS in WORKS_ON represents the HOURS attribute of the relation type. The primary key of the WORKS_ON relation is the combination of the foreign key attributes {ESSN, PNO}.



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Step 6: Mapping of Multivalued attributes.

- For each multi-valued attribute A, create a new relation R.
 - This relation R will include =
 - an attribute corresponding to A + the primary key attribute K-as a foreign key in R-of the relation that represents the entity type of relationship type that has A as an attribute.
- The primary key of R =combination of A and K.
- If the multivalued attribute is composite, include its simple

components.

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• Step 6: Mapping of Multivalued attributes.

Example:

The relation DEPT_LOCATIONS is created. The attribute DLOCATION represents the multivalued attribute LOCATIONS of DEPARTMENT, while DNUMBER-as foreign key-represents the primary key of the DEPARTMENT relation.

The primary key of R is the combination of {DNUMBER, DLOCATION}.



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- Step 7: Mapping of N-ary Relationship Types.
 - For each n-ary relationship type R, where n>2, create a new relationship S to represent R.
 - Include as foreign key attributes in S the primary keys of the relations that represent the participating entity types.
 - Also include any simple attributes of the n-ary relationship type (or simple components of composite attributes) as attributes of S.

Step 7: Mapping of N-ary Relationship Types.

Example:

The relationship type SUPPY in the ER below. This can be mapped to the relation SUPPLY shown in the relational schema, whose primary key is the combination of the three foreign keys {SNAME, PARTNO, PROJNAME}

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FIGURE 4.11

Ternary relationship types. (a) The SUPPLY relationship.



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FIGURE 7.3

Mapping the *n*-ary relationship type SUPPLY from Figure 4.11a.

SUPPLIER



PROJECT

PROJNAME	•••
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PART

PARTNO	• • •
--------	-------

SUPPLY

SNAME	PROJNAME	PARTNO	QUANTITY

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Summary of Mapping constructs and constraints

 Table 7.1 Correspondence between ER and Relational Models

ER Model

Key attribute

Relational Model

Entity type 1:1 or 1:N relationship type M:N relationship type *n*-ary relationship type Simple attribute Composite attribute Multivalued attribute Value set

"Entity" relation Foreign key (or "relationship" relation) "Relationship" relation and two foreign keys "Relationship" relation and n foreign keys Attribute Set of simple component attributes Relation and foreign key Domain Primary (or secondary) key

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Mapping EER Model Constructs to Relations

• Step8: Options for Mapping Specialization or Generalization.

Convert each specialization with m subclasses $\{S_1, S_2, ..., S_m\}$ and generalized superclass C, where the attributes of C are $\{k, a_1, ..., a_n\}$ and k is the (primary) key, into relational schemas using one of the four following options:

Option 8A: Multiple relations-Superclass and subclasses.

- Create a relation L for Superclass C with attributes $Attrs(L) = \{k, a_1, \dots a_n\}$ and PK(L) = k.
- Create a relation L_i for each subclass S_i , 1 < i < m, with the attributes,

Attrs(L_i) = {k} U {attributes of S_i } and PK(L_i)=k.

- This option works for any specialization (total or partial, disjoint or over-lapping).

FIGURE 4.4 EER diagram notation for an attributedefined specialization on JobType.



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FIGURE 7.4

Options for mapping specialization or generalization. (a) Mapping the EER schema in Figure 4.4 using option 8A.

(a) EMPLOYEE

<u>SSN</u>	FName	MInit	LName	BirthDate	Address	JobType



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Mapping EER Model Constructs to Relations

• Step8: Options for Mapping Specialization or Generalization.

Option 8B: Multiple relations-Subclass relations only

- Create a relation L_i for each subclass S_i , 1 < i < m, with the attributes Attr $(L_i) = \{$ attributes of $S_i \} U \{k, a_1, \dots, a_n \}$ and PK $(L_i) = k$.
- This option only works for a specialization whose subclasses are total (every entity in the superclass must belong to (at least) one of the subclasses).

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FIGURE 4.3

Generalization. (b) Generalizing CAR and TRUCK into the superclass VEHICLE.



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FIGURE 7.4

Options for mapping specialization or generalization. (b) Mapping the EER schema in Figure 4.3b using option 8B.

(b) CAR

VehicleId	LicensePlateNo	Price	MaxSpeed	NoOfPassengers
-----------	----------------	-------	----------	----------------

TRUCK

VehicleId	LicensePlateNo	Price	NoOfAxles	
-----------	----------------	-------	-----------	--

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Mapping EER Model Constructs to Relations (cont)

Option 8C: Single relation with one type attribute.

- Create a single relation L with attributes,

Attrs(L) = {k, a_1 ,... a_n } U {attributes of S₁} U...U {attributes of S_m} U {t} and PK(L) = k.

- The attribute t is called a type (or **discriminating**) attribute that indicates the subclass to which each tuple belongs

FIGURE 4.4 EER diagram notation for an attributedefined specialization on JobType.

(C)

EMPLOYEE

FName

SSN



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FIGURE 7.4

FMPI OYFF

Options for mapping specialization or generalization. (c) Mapping the EER schema in Figure 4.4 using option 8C.

(C)

SSN	FName	Mlnit	LName	BirthDate	Address	JobType	TypingSpeed	TGrade	

Discriminating

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Mapping EER Model Constructs to Relations (cont)

Option 8D: Single relation with multiple type attributes.

Create a single relation schema L with attributes Attrs (L) = $\{k,a_1,...a_n\}$ U {attributes of S₁} U...U {attributes of S_m} U {t₁, t₂,...,t_m} and PK(L) = k. Each t_i, 1 < I < m, is a Boolean type attribute indicating whether a tuple belongs to the subclass S_i.

FIGURE 4.5

EER diagram notation for an overlapping (nondisjoint) specialization.





Mapping EER Model Constructs to Relations (cont)

Mapping of Shared Subclasses (Multiple Inheritance)

-A shared subclass, such as STUDENT_ASSISTANT, is a subclass of several classes, indicating multiple inheritance.

- These classes must all have the same key attribute; otherwise, the shared subclass would be modeled as a category.

Apply any of the options discussed in Step 8 to a shared subclass, subject to the restriction discussed in Step 8 of the mapping algorithm. Below both 8C and 8D are used for the shared class STUDENT_ASSISTANT.

FIGURE 4.7 A specialization lattic with multiple inheritar for a UNIVERSITY database.



FIGURE 7.5 Mapping the EER specialization lattice in Figure 4.6 using multiple options.



Mapping EER Model Constructs to Relations (cont)

- Step 9: Mapping of Union Types (Categories).
 - For mapping a category whose defining superclass have different keys, it is customary to specify a new key attribute, called a surrogate key, when creating a relation to correspond to the category.
 - In the example below we can create a relation OWNER to correspond to the OWNER category and include any attributes of the category in this relation. The primary key of the OWNER relation is the surrogate key, which we called OwnerId.
 - The most common type of surrogate key is an incrementing integer, such as an auto_increment column in MySQL, or a sequence in Oracle, or an

identity column in SQL Server.

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FIGURE 4.8 Two categories (union types): OWNER and REGISTERED_VEHICLE.



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FIGURE 7.6

Mapping the EER categories (union types) in Figure 4.7 to

relations.



PERSON

SSN DriverLicense	No Name	Address	
-------------------	---------	---------	--

BANK

BName BAddress Ownerld

COMPANY

<u>CName</u>	CAddress	Ownerld
--------------	----------	---------

OWNER

Ownerld

REGISTERED_VEHICLE

VehicleId I	icensePlateNumber
-------------	-------------------

CAR

VehicleId CStyle	CMake	CModel	
------------------	-------	--------	--

TRUCK

VehicleId	TMake	TModel	Tonnage	TYear
-----------	-------	--------	---------	-------

OWNS

Ownerld	VehicleId	PurchaseDate	LienOrRegular

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Mapping Exercise



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Mapping Exercise Ans.

Exercise 7.4.

