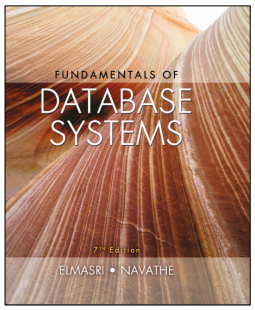
Fundamentals of Database Systems

Seventh Edition



Chapter 9

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

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

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

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Goals during Mapping

- Preserve all information (that includes all attributes)
- Maintain the constraints to the extent possible (Relational Model cannot preserve all contstraints- e.g., max cardinality ratio such as 1:10 in ER; exhaustive classification into subtypes, e.g., STUDENTS are specialized into Domestic and Foreign)
- Minimize null values

The mapping procedure described has been implemented in many commercial tools.

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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

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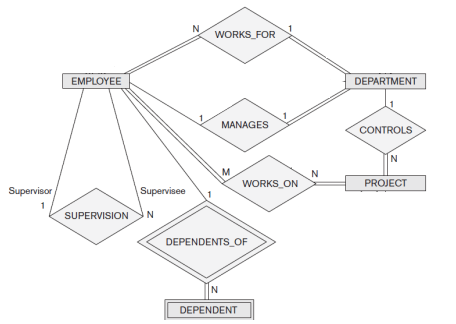
Figure 9.1
The ER conceptual schema diagram for the COMPANY database.



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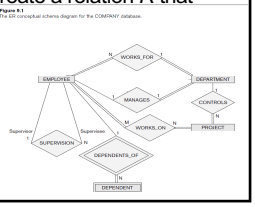
ER-to-Relational Mapping Algorithm

- 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



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ER-to-Relational Mapping Algorithm

– Called **entity relations**
  - Each tuple represents an entity instance
  - Example: We create the relations EMPLOYEE, DEPARTMENT, and PROJECT in the relational schema corresponding to the regular entities in the ER diagram.
  - SSN, DNUMBER, and PNUMBER are the primary keys for the relations EMPLOYEE, DEPARTMENT, and PROJECT as shown.

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary

DEPARTMENT

Dname	Dnumber

PROJECT

Pname	Pnumber	Plocation

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ER-to-Relational Mapping Algorithm

- Step 1: Mapping of Regular Entity Types

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary

DEPARTMENT

Dname	Dnumber

PROJECT

Pname	Pnumber	Plocation

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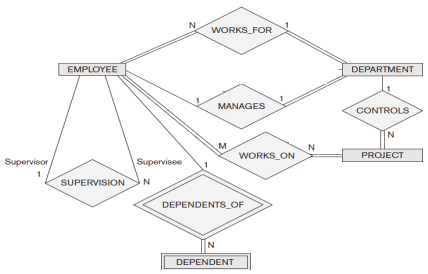
Figure 9.1 The ER Conceptual Schema Diagram for the COMPANY Database

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



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ER-to-Relational Mapping Algorithm

- **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*

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

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ER-to-Relational Mapping Algorithm

- **Example:** Create the relation DEPENDENT in this step to correspond to 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.

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

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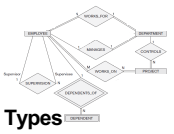
ER-to-Relational Mapping Algorithm



- **Step 3: Mapping of Binary 1:1 Relation Types**
  – For each binary 1:1 relationship type
    - Identify relations that correspond to entity types participating in *R*
- There are three possible approaches:
  1. **Foreign Key (2 relations) approach**
  2. **Merged relation (1 relation) option**
  3. **Cross-reference or relationship relation (3 relations) option:**

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

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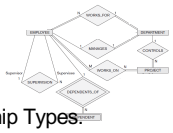
ER-to-Relational Mapping Algorithm



- 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*

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

PROJECT

Pname	Pnumber	Plocation	Dnum

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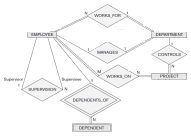
ER-to-Relational Mapping Algorithm

- Example: 1:N relationship types WORKS_FOR, CONTROLS, and SUPERVISION in the figure.
  - For WORKS_FOR we include the primary key DNUMBER of the DEPARTMENT relation as foreign key in the EMPLOYEE relation and call it DNO.



DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

PROJECT

Pname	Pnumber	Plocation	Dnum

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

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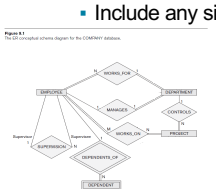
ER-to-Relational Mapping Algorithm

- **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



WORKS_ON

Essn	Pno	Hours

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ER-to-Relational Mapping Algorithm

- 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}.

WORKS_ON

Essn	Pno	Hours

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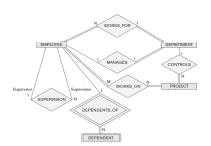
ER-to-Relational Mapping Algorithm

- **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



DEPT_LOCATIONS

Dnumber	Dlocation

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ER-to-Relational Mapping Algorithm

- **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}.

DEPT_LOCATIONS

Dnumber	Dlocation

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ER-to-Relational Mapping Algorithm (cont'd.)

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.
d. Relation representing multivalued attribute after step 6.

(a) EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary

DEPARTMENT

Dname	Dnumber

PROJECT

Pname	Pnumber	Plocation

(b) DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

(c) WORKS_ON

Essn	Pno	Hours

(d) DEPT_LOCATIONS

Dnumber	Dlocation

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ER-to-Relational Mapping Algorithm

- **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

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ER-to-Relational Mapping Algorithm (14 of 14)

- **Example:** The relationship type SUPPY in the ER on the next slide.
  - 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, PART NO, PROJNAME}

Figure 9.4
Mapping the *n*-ary relationship type SUPPLY from Figure 7.17(a).

SUPPLIER

Sname	...

PROJECT

Proj_name	...

PART

Part_no	...

SUPPLY

Sname	Proj_name	Part_no	Quantity

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Figure 9.2 Result of Mapping the COMPANY ER Schema into a Relational Database Schema

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

DEPT_LOCATIONS

Dnumber	Dlocation

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

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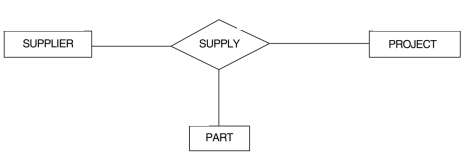
Figure 3.17 Ternary Relationship: Supply

(a)



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Mapping the *n*-ary relationship type SUPPLY

SUPPLIER

Sname	...

PROJECT

Proj_name	...

PART

Part_no	...

SUPPLY

Sname	Proj_name	Part_no	Quantity

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Summary of Mapping Constructs and Constraints

Table 9.1 Correspondence between ER and Relational Models

ER Model	Relational Model
Entity type	**Entity** relation
1:1 or 1:N relationship type	Foreign key (or **relationship** relation)
M:N relationship type	**Relationship** relation and **two** foreign keys
n-ary relationship type	**Relationship** relation and *n* foreign keys
Simple attribute	Attribute
Composite attribute	Set of simple component attributes
Multivalued attribute	Relation and foreign key
Value set	Domain
Key attribute	Primary (or secondary) key

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Mapping of Generalization and Specialization Hierarchies to a Relational Schema

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Mapping EER Model Constructs to Relations

- **Step 8: 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:
    - A: Multiple relations-Superclass and subclasses

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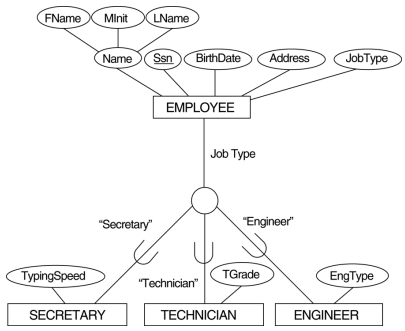
Figure 4.4 EER Diagram Notation for an Attribute-Defined Specialization on JobType



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Mapping the EER Schema in Figure 4.4 (see slide 27) Using Option 8A

(a) EMPLOYEE

SSN	FName	MInit	LName	BirthDate	Address	JobType

SECRETARY	
SSN	TypingSpeed

TECHNICIAN	
SSN	TGrade

ENGINEER	
SSN	EngType

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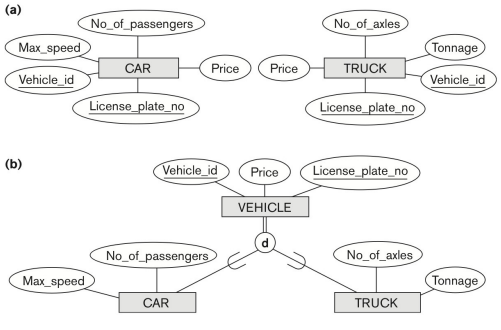
Figure 4.3 (b) Generalizing CAR and TRUCK into the Superclass VEHICLE



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