



SOFTENG 351

Fundamentals of Database Systems

Relational Database Design by ER to Relational Mapping



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.



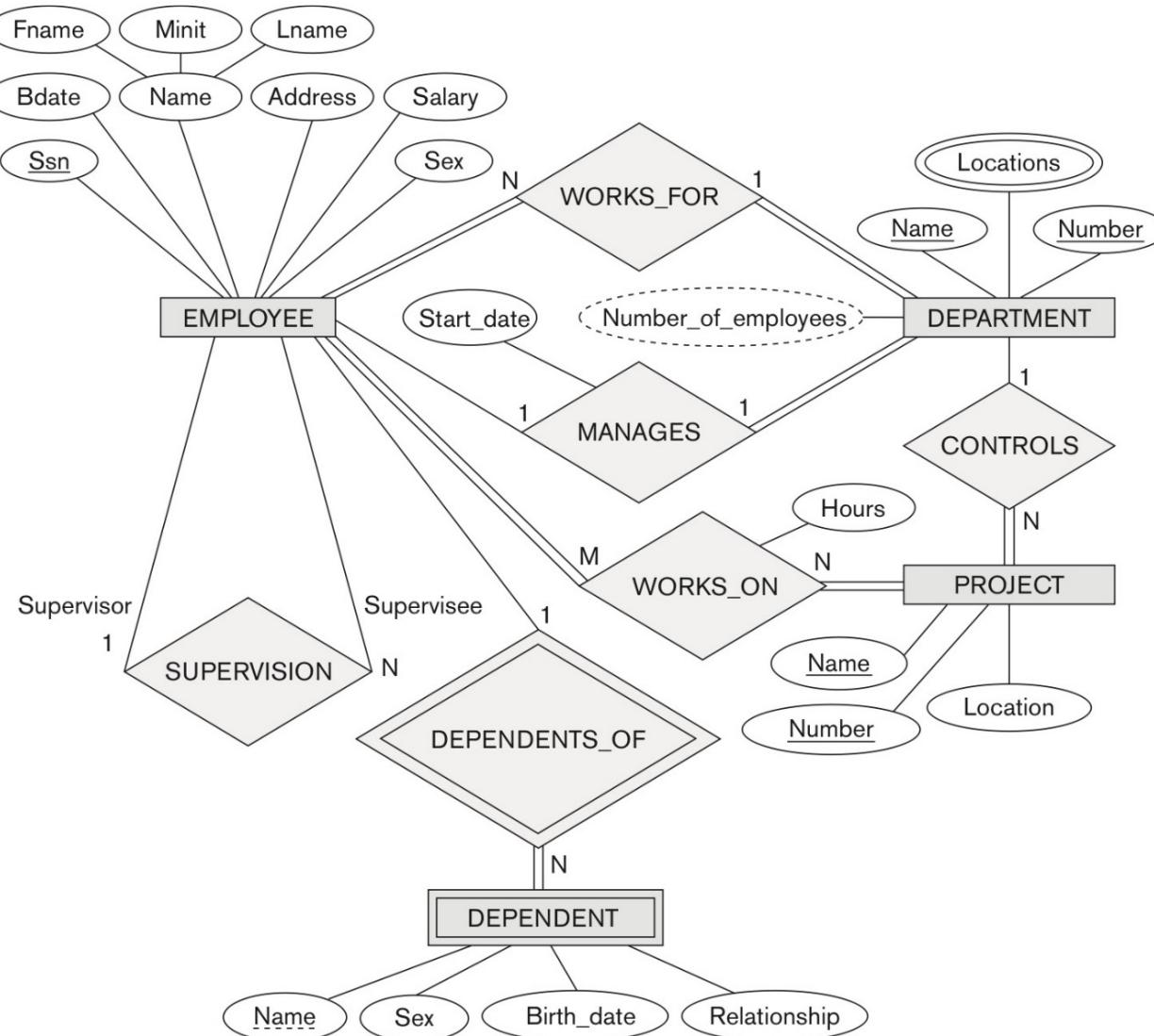
GOALS during Mapping

- ▶ Preserve all information (that includes all attributes)
- ▶ Maintain the constraints to the extent possible
(Relational Model cannot preserve all constraints – e.g., max cardinality ratio such as 1:10 in an ER relationship type).
- ▶ Minimize null values

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



The ER conceptual schema diagram for the COMPANY database.





ER-to-Relational Mapping Algorithm

▶ **Step I: Mapping of Regular Entity Types.**

- ▶ For each regular (strong) entity type E in the ER diagram, create a relation R that includes all the simple attributes of E.
- ▶ Composite attributes are represented by their ungrouped components.
- ▶ 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.



ER-to-Relational Mapping Algorithm

- ▶ **Step I: Mapping of Regular Entity Types.**
- ▶ 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	<u>Ssn</u>	Bdate	Address	Sex	Salary
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DEPARTMENT

Dname	<u>Dnumber</u>
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PROJECT

Pname	<u>Pnumber</u>	Plocation
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ER-to-Relational Mapping Algorithm (contd.)

▶ **Step 2: Mapping of Weak Entity Types**

- ▶ For each weak entity type W in the ER diagram with owner entity type E , create a relation R & include all simple attributes (or simple components of composite attributes) of W as attributes of R .
- ▶ Also, 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.



ER-to-Relational Mapping Algorithm (contd.)

- ▶ **Step 2: Mapping of Weak Entity Types**
- ▶ **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

<u>Essn</u>	<u>Dependent_name</u>	Sex	Bdate	Relationship
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ER-to-Relational Mapping Algorithm (contd.)

- ▶ **Step 3: Mapping of Binary 1:1 Relation Types**
 - ▶ For each binary 1:1 relationship type R in the ER diagram, identify the relations S and T that correspond to the entity types participating in R.
 - ▶ There are three possible approaches:
 - I. **Foreign Key (2 relations) approach:** Choose one of the relations (e.g., S) 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.



ER-to-Relational Mapping Algorithm (contd.)

- ▶ **Step 3: Mapping of Binary 1:1 Relation Types**
- ▶ There are three possible approaches:
 - I. **Foreign Key (2 relations) approach:**
 - ▶ 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.

EMPLOYEE

Fname	Minit	Lname	<u>Ssn</u>	Bdate	Address	Sex	Salary
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DEPARTMENT

Dname	<u>Dnumber</u>	Mgr_ssn	Mgr_start_date
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ER-to-Relational Mapping Algorithm (contd.)

► Step 3: Mapping of Binary 1:1 Relation Types

2. **Merged relation (1 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 (3 relations) option:** The third alternative is to set up a third relation R for the purpose of cross-referencing the primary keys of the two relations S and T representing the entity types.



ER-to-Relational Mapping Algorithm (contd.)

- ▶ **Step 4: Mapping of Binary 1:N Relationship Types.**
 - ▶ **The foreign key approach:**
 - ▶ 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.
 - ▶ **The relationship relation approach:** An alternative approach uses a relationship relation (cross referencing relation) option as in the third option for binary 1:1 relationships.



ER-to-Relational Mapping Algorithm (contd.)

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

▶ The foreign key approach:

- ▶ 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.

EMPLOYEE

Fname	Minit	Lname	<u>Ssn</u>	Bdate	Address	Sex	Salary	Super_ssn	Dno
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DEPARTMENT

Dname	<u>Dnumber</u>	Mgr_ssn	Mgr_start_date
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PROJECT

Pname	<u>Pnumber</u>	Plocation	Dnum
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ER-to-Relational Mapping Algorithm (contd.)

- ▶ **Step 5: Mapping of Binary M:N Relationship Types.**
- ▶ **The relationship relation (cross-reference) option:**
 - ▶ For each regular binary M:N relationship type R, *create a new relation S to represent R. This is a relationship relation.*
 - ▶ 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.



ER-to-Relational Mapping Algorithm (contd.)

- ▶ **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}.

WORKS_ON

<u>Essn</u>	<u>Pno</u>	Hours
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ER-to-Relational Mapping Algorithm (contd.)

- ▶ **Step 6: Mapping of Multivalued attributes.**
 - ▶ For each multivalued attribute A, create a new relation R.
 - ▶ This relation R will include an attribute corresponding to A, plus 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 is the combination of A and K. If the multivalued attribute is composite, we include its simple components.



ER-to-Relational Mapping Algorithm (contd.)

- ▶ **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}.

DEPT_LOCATIONS	
Dnumber	Dlocation



ER-to-Relational Mapping Algorithm (contd.)

- ▶ **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.

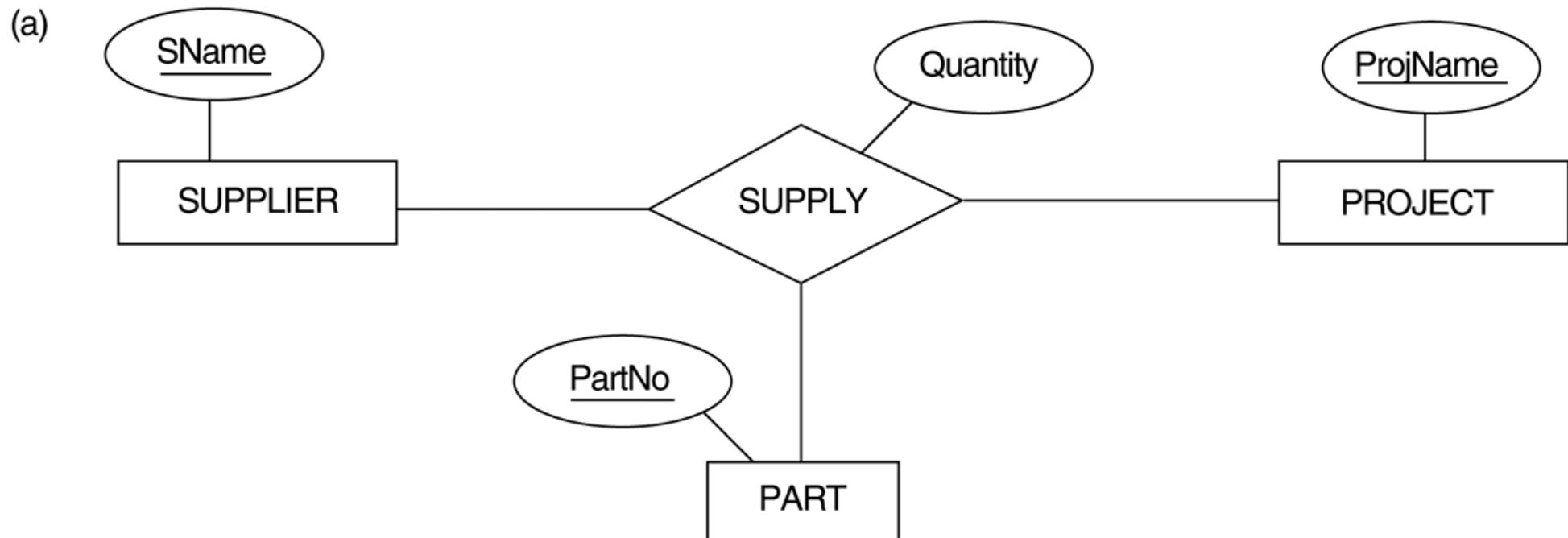


ER-to-Relational Mapping Algorithm (contd.)

- ▶ **Step 7: Mapping of N-ary Relationship Types.**
- ▶ **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, PARTNO, PROJNAME}

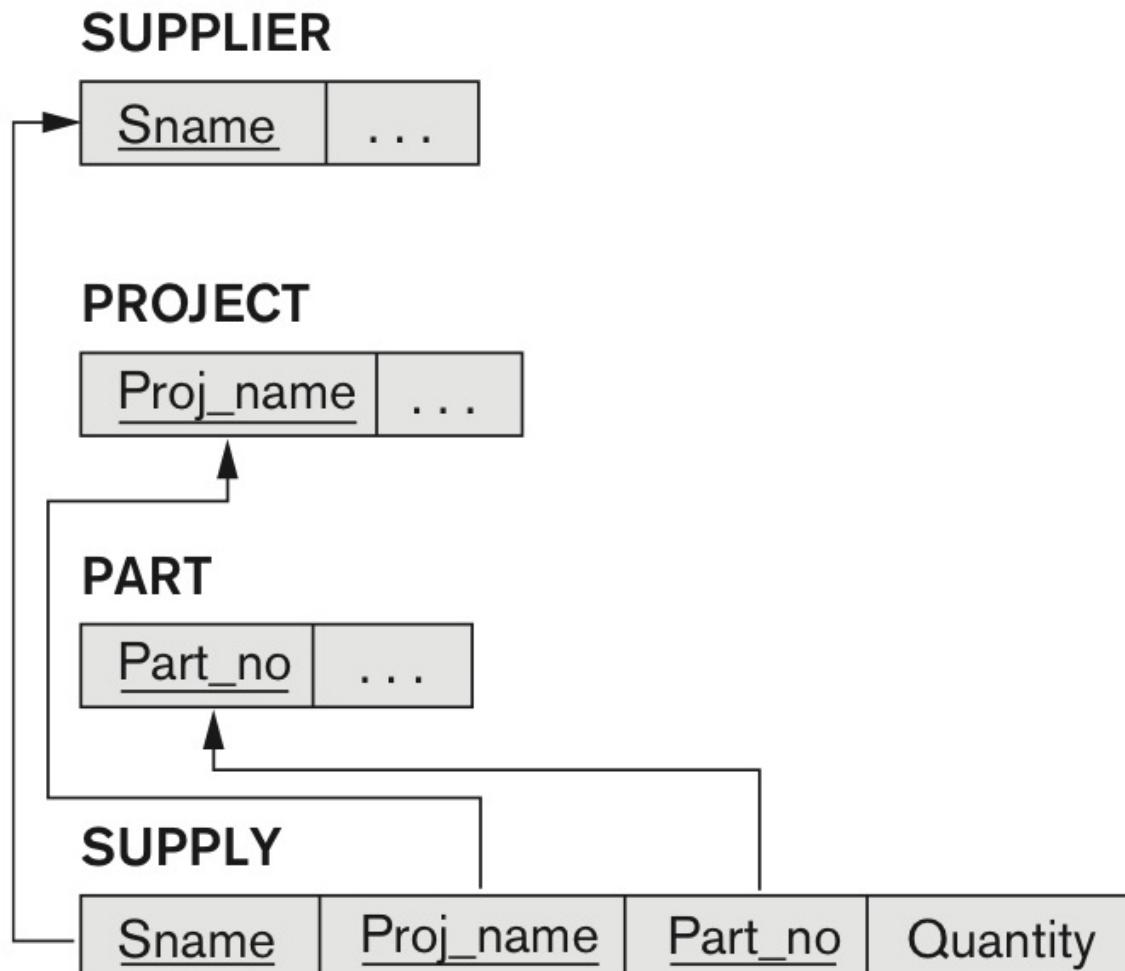


Example: TERNARY RELATIONSHIP: SUPPLY





Example: TERNARY RELATIONSHIP: SUPPLY





Result of mapping the COMPANY ER diagram into a relational database schema.

EMPLOYEE

Fname	Minit	Lname	<u>Ssn</u>	Bdate	Address	Sex	Salary	Super_ssn	Dno
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DEPARTMENT

Dname	<u>Dnumber</u>	Mgr_ssn	Mgr_start_date
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DEPT_LOCATIONS

<u>Dnumber</u>	<u>Dlocation</u>
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PROJECT

Pname	<u>Pnumber</u>	<u>Plocation</u>	Dnum
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WORKS_ON

<u>Essn</u>	<u>Pno</u>	Hours
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DEPENDENT

<u>Essn</u>	Dependent_name	Sex	Bdate	Relationship
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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	<i>Entity</i> relation
1:1 or 1:N relationship type	Foreign key (or <i>relationship</i> relation)
M:N relationship type	<i>Relationship</i> relation and two foreign keys
<i>n</i> -ary relationship type	<i>Relationship</i> relation and <i>n</i> 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



Summary

- ▶ The Relational Model has been implemented in many commercial and open source DBMSs.
- ▶ We present the algorithms for mappings from ER diagram into Relation Model, which has been implemented in many tools.
- ▶ **ER-to-Relational Mapping Algorithm**
 - ▶ Step 1: Mapping of Regular Entity Types
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 - ▶ 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.