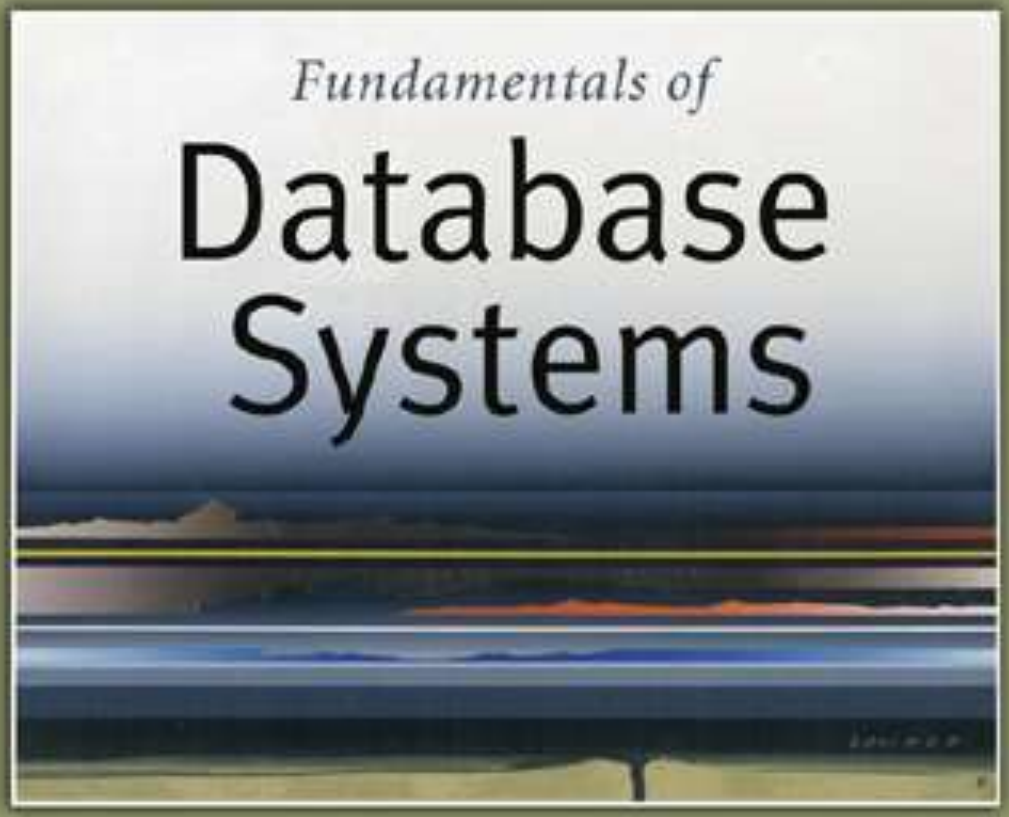


5th Edition

Elmasri / Navathe

Constraints on Relationships

- Constraints on Relationship Types
  - (Also known as ratio constraints)
  - **Cardinality Ratio** (specifies *maximum* participation)
    - One-to-one (1:1)
    - One-to-many (1:N) or Many-to-one (N:1)
    - Many-to-many (M:N)

ER DIAGRAM – Relationship Types are:

WORKS_FOR, MANAGES, WORKS_ON, CONTROLS, SUPERVISION, DEPENDENTS_OF

Works_For

Emp	Dept
1	1
N	1

N : 1

Manages

Emp	Dept
1	1
1	1

1 : 1

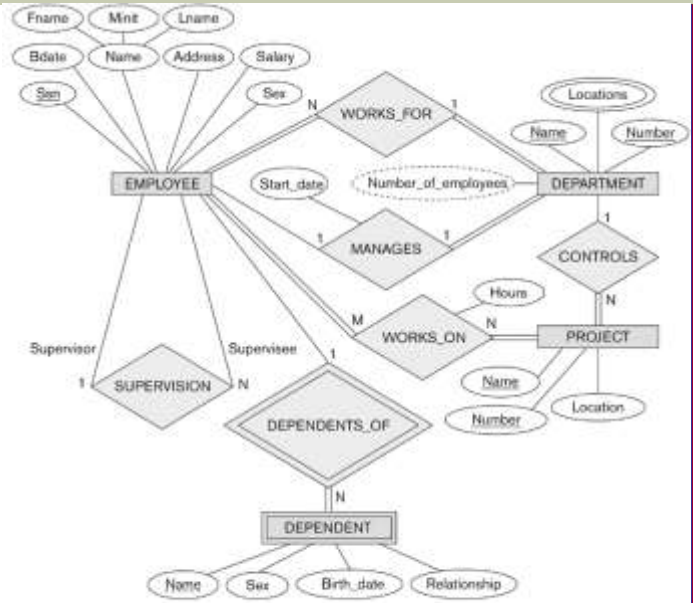


Figure 3.2
...a diagram for the COMPANY database. The diagrammatic notation ... gradually throughout this chapter.

Works_On

Emp	Project
1	N
N	1

M : N

Supervision

Supervisor	Supervisee
1	N
1	1

1 : N

ER DIAGRAM – Relationship Types are:

WORKS_FOR, MANAGES, WORKS_ON, CONTROLS, SUPERVISION, DEPENDENTS_OF

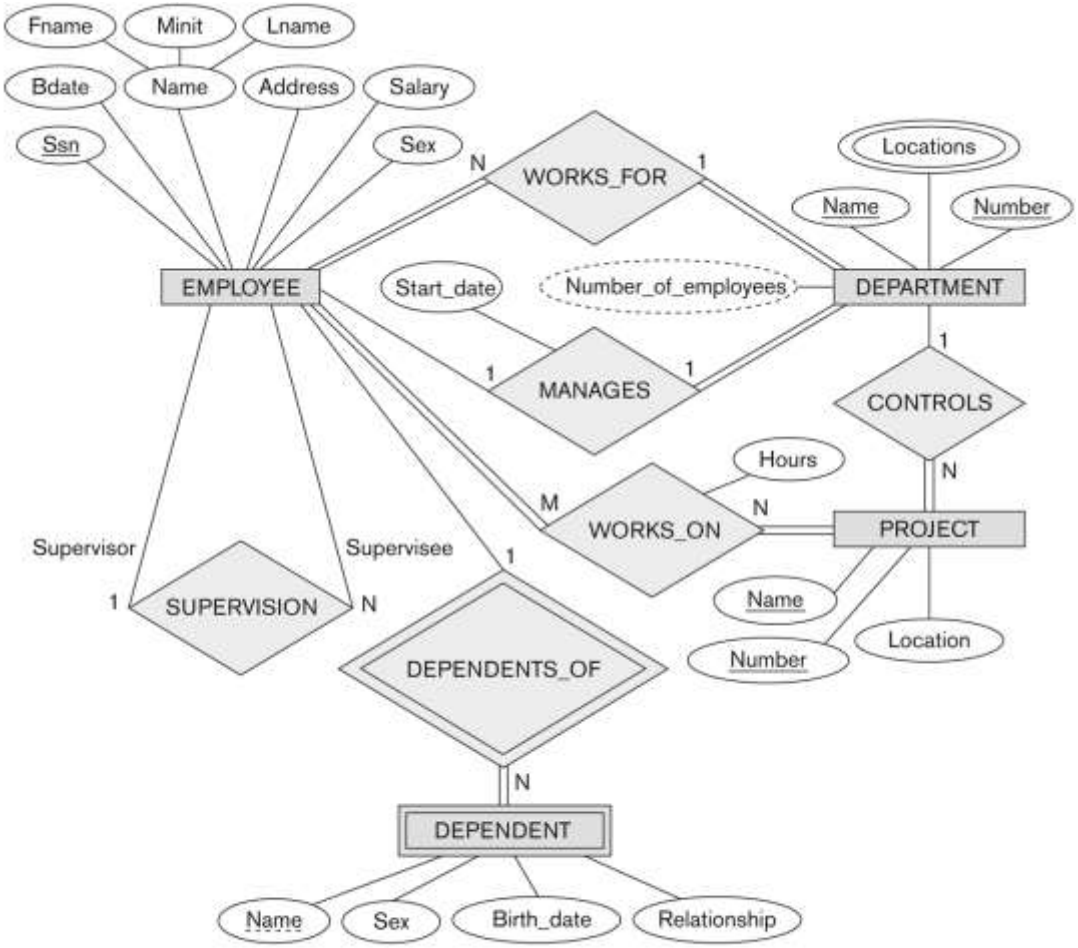


Figure 3.2
An ER schema diagram for the COMPANY database. The diagrammatic notation is introduced gradually throughout this chapter.

Constraints on Relationships

- Constraints on Relationship Types
  - **Existence Dependency Constraint** (specifies ***minimum*** participation) (also called participation constraint)
    - zero (**optional** participation, not existence-dependent)
    - one or more (**mandatory** participation, existence-dependent)

Notation for Constraints on Relationships

- Cardinality ratio (of a binary relationship): 1:1, 1:N, N:1, or M:N
  - Shown by placing appropriate numbers on the relationship edges.
- Participation constraint (on each participating entity type): total (called existence dependency) or partial.
  - Total shown by double line, partial by single line.
- NOTE: These are easy to specify for Binary Relationship Types.

ER DIAGRAM – Relationship Types are:

WORKS_FOR, MANAGES, WORKS_ON, CONTROLS, SUPERVISION, DEPENDENTS_OF

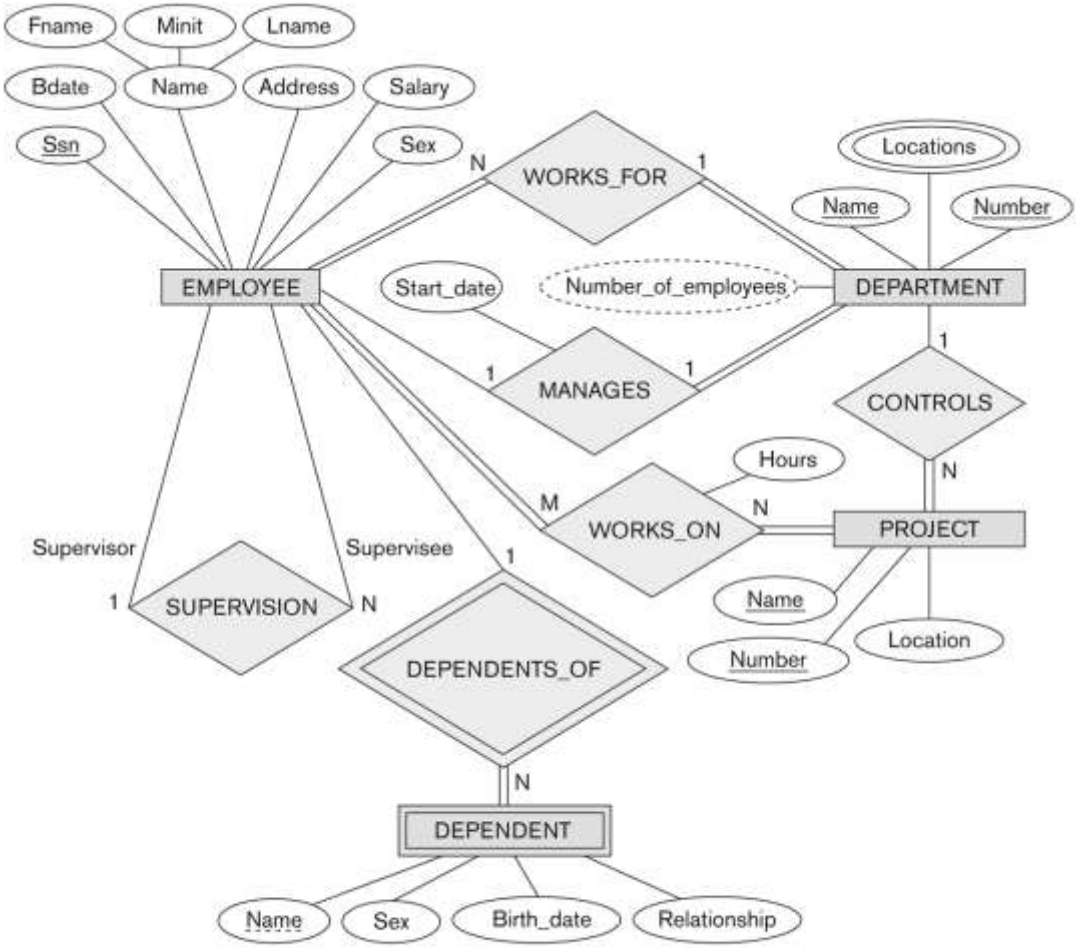


Figure 3.2
An ER schema diagram for the COMPANY database. The diagrammatic notation is introduced gradually throughout this chapter.

Attributes of Relationship types

- A relationship type can have attributes:
  - For example, HoursPerWeek of WORKS_ON
  - Its value for each relationship instance describes the number of hours per week that an EMPLOYEE works on a PROJECT.
    - A value of HoursPerWeek depends on a particular (employee, project) combination
  - Most relationship attributes are used with M:N relationships
    - In **1:N relationships**, they can be transferred to the entity type on **the N-side of the relationship**
    - For example, if the WORKS_FOR relationship also has an attribute Start_date

Example Attribute of a Relationship Type: Hours of WORKS_ON

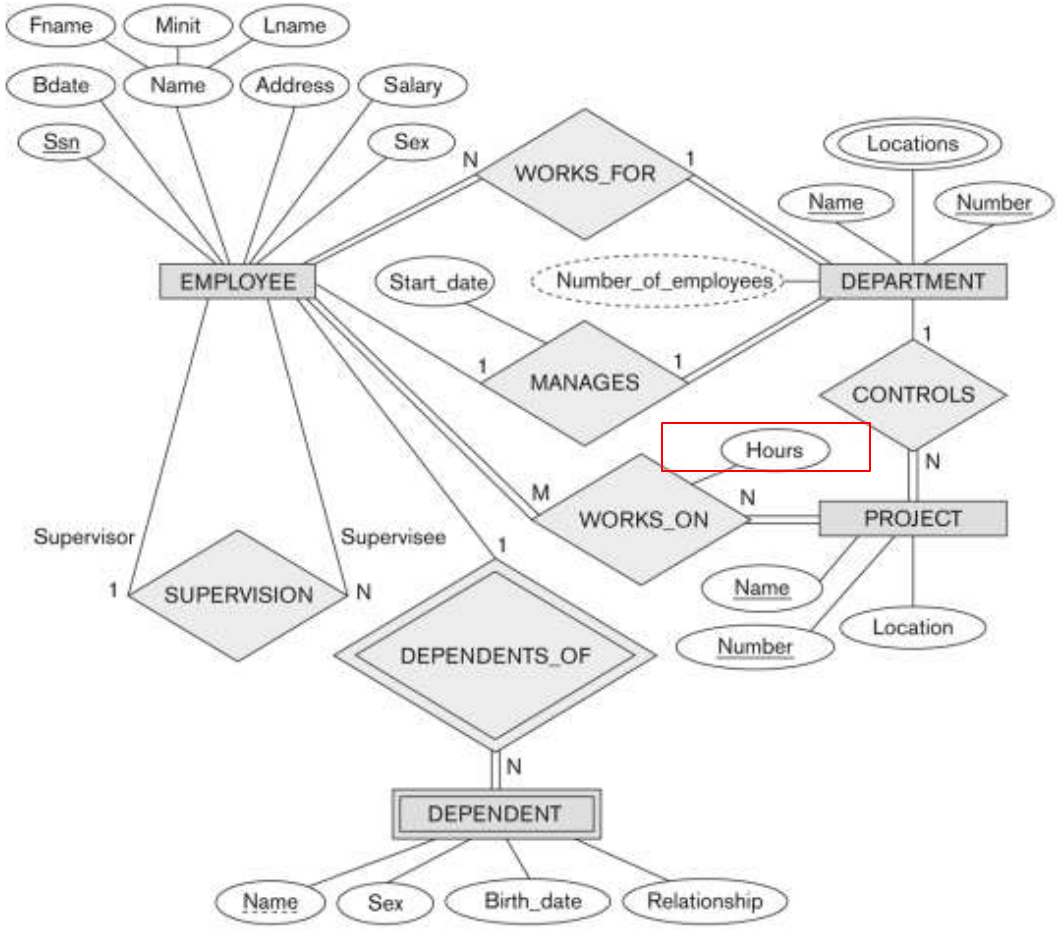
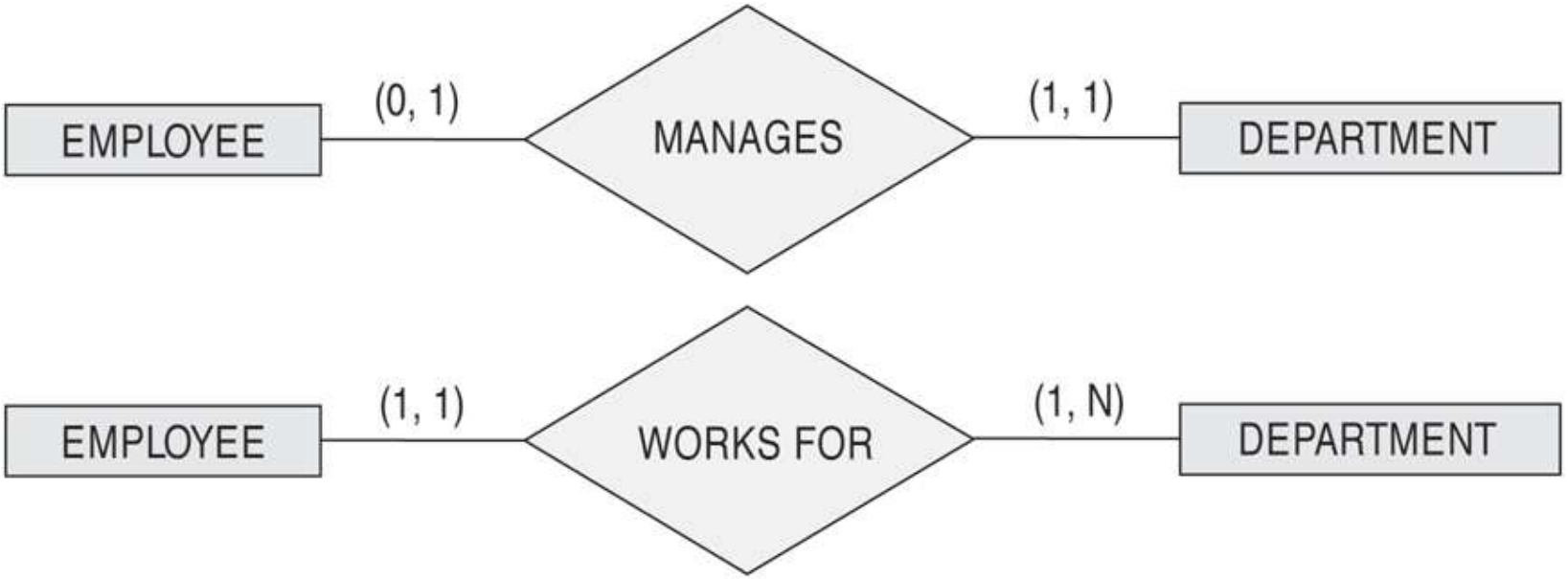


Figure 3.2
An ER schema diagram for the COMPANY database. The diagrammatic notation is introduced gradually throughout this chapter.

Alternative (min, max) notation for relationship structural constraints:

- Specified on each participation of an entity type E in a relationship type R
- Specifies that each entity e in E participates in at least *min* and at most *max* relationship instances in R
- Default(no constraint): min=0, max=n (signifying no limit)
- Must have min≤max, min≥0, max ≥1
- Derived from the knowledge of mini-world constraints
- Examples:
  - A department has exactly one manager and an employee can manage at most one department.
    - Specify (0,1) for participation of EMPLOYEE in MANAGES
    - Specify (1,1) for participation of DEPARTMENT in MANAGES
  - An employee can work for exactly one department but a department can have any number of employees.
    - Specify (1,1) for participation of EMPLOYEE in WORKS_FOR
    - Specify (0,n) for participation of DEPARTMENT in WORKS_FOR

The (min,max) notation for relationship constraints



Read the min,max numbers next to the entity type and looking **away from** the entity type

COMPANY ER Schema Diagram using (min, max) notation

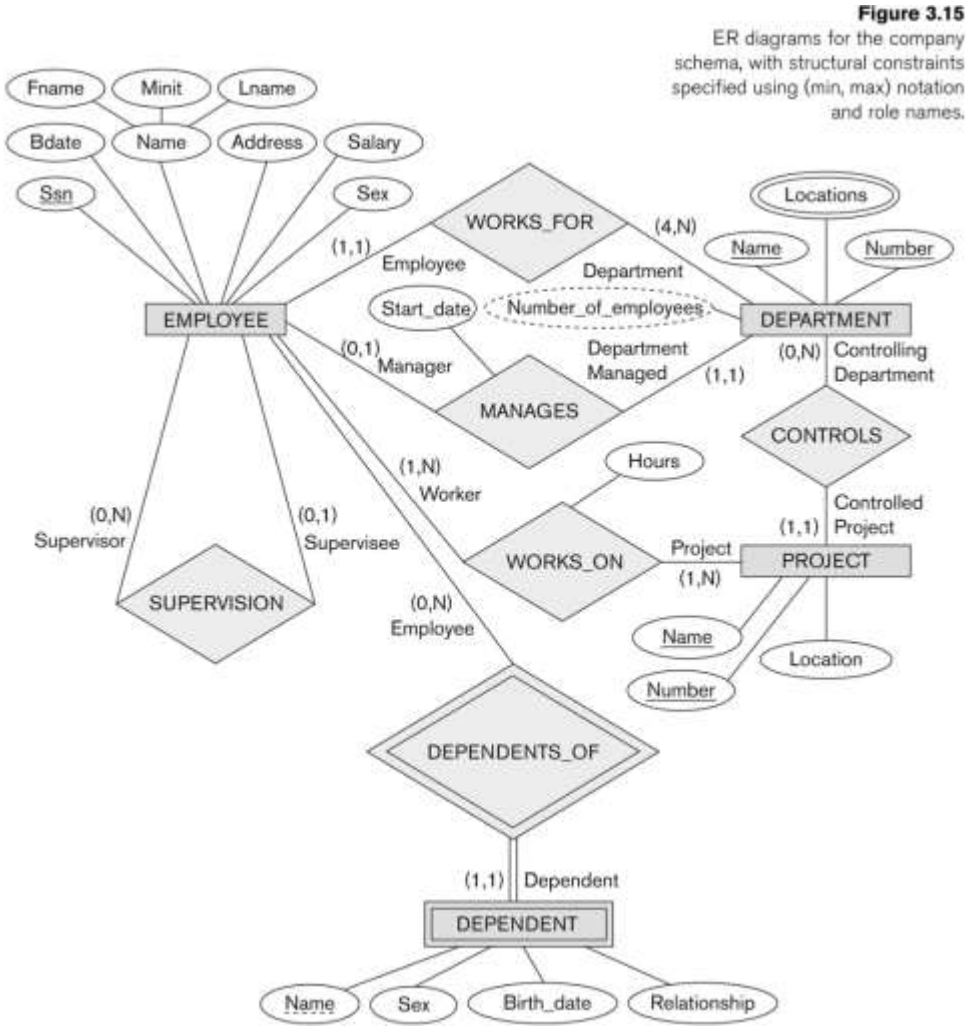
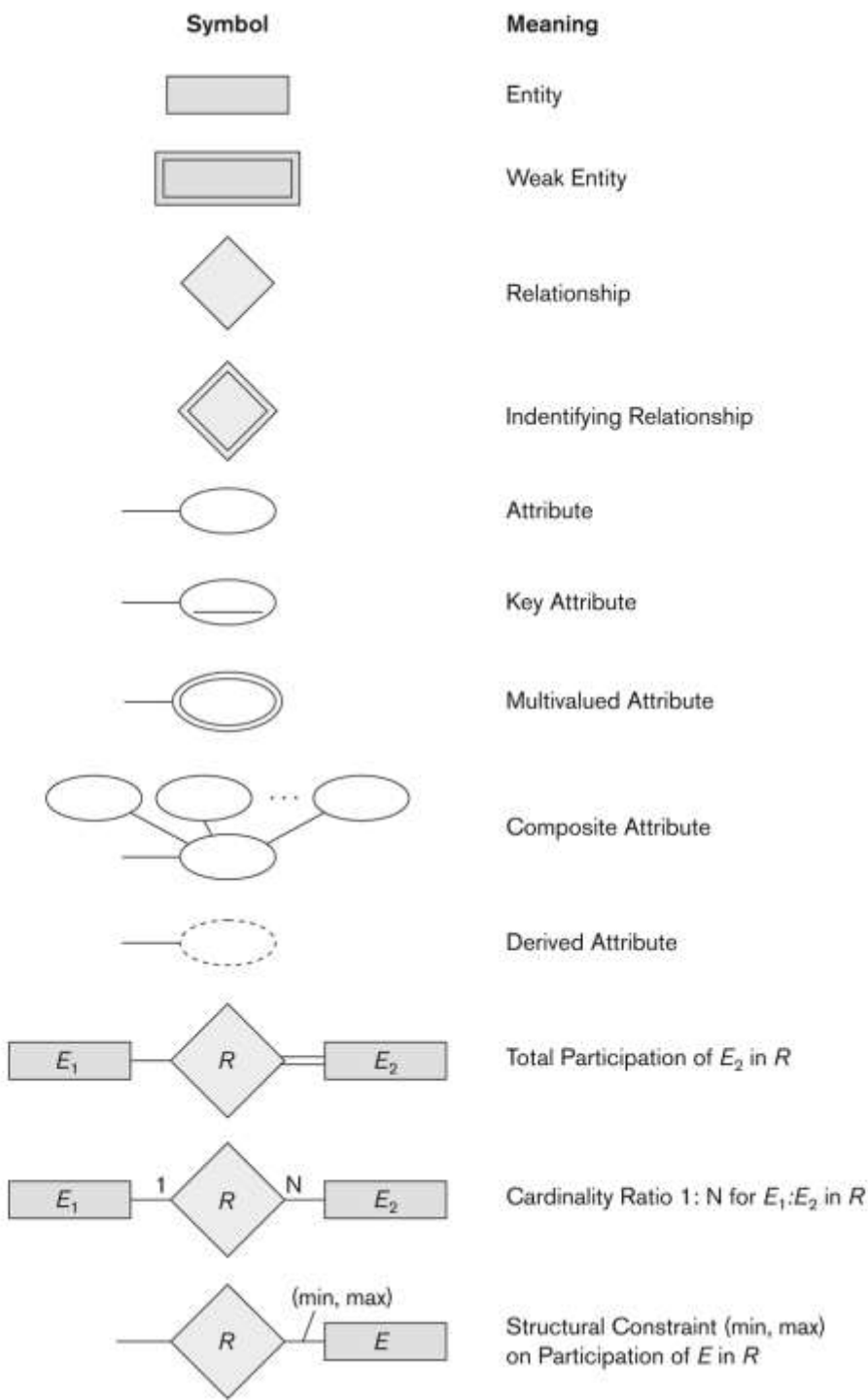


Figure 3.15
ER diagrams for the company schema, with structural constraints specified using (min, max) notation and role names.

Summary of notation for ER diagrams

Figure 3.14
Summary of the notation for ER diagrams.



Alternative diagrammatic notation

- ER diagrams is one popular example for displaying database schemas
- Many other notations exist in the literature and in various database design and modeling tools
- UML class diagrams is representative of another way of displaying ER concepts that is used in several commercial design tools

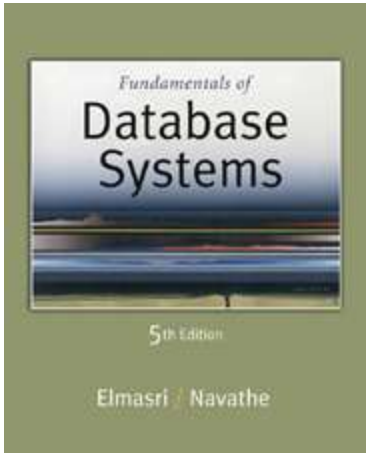
- More than relation between the same entities
- Self relation
- No isolated entity without relation
- No entity for system
- Weak entity can be multivalued composite attribute
- No entity without Key
- No relation without cardinalty reation

Chapter Summary

- ER Model Concepts: Entities, attributes, relationships
- Constraints in the ER model
- Using ER in step-by-step conceptual schema design for the COMPANY database
- ER Diagrams - Notation
- Alternative Notations – UML class diagrams, others

Chapter 7

Relational Database Design by ER--to-Relational Mapping



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. (next lecture)

FIGURE 7.1
The ER conceptual schema diagram for the COMPANY database.

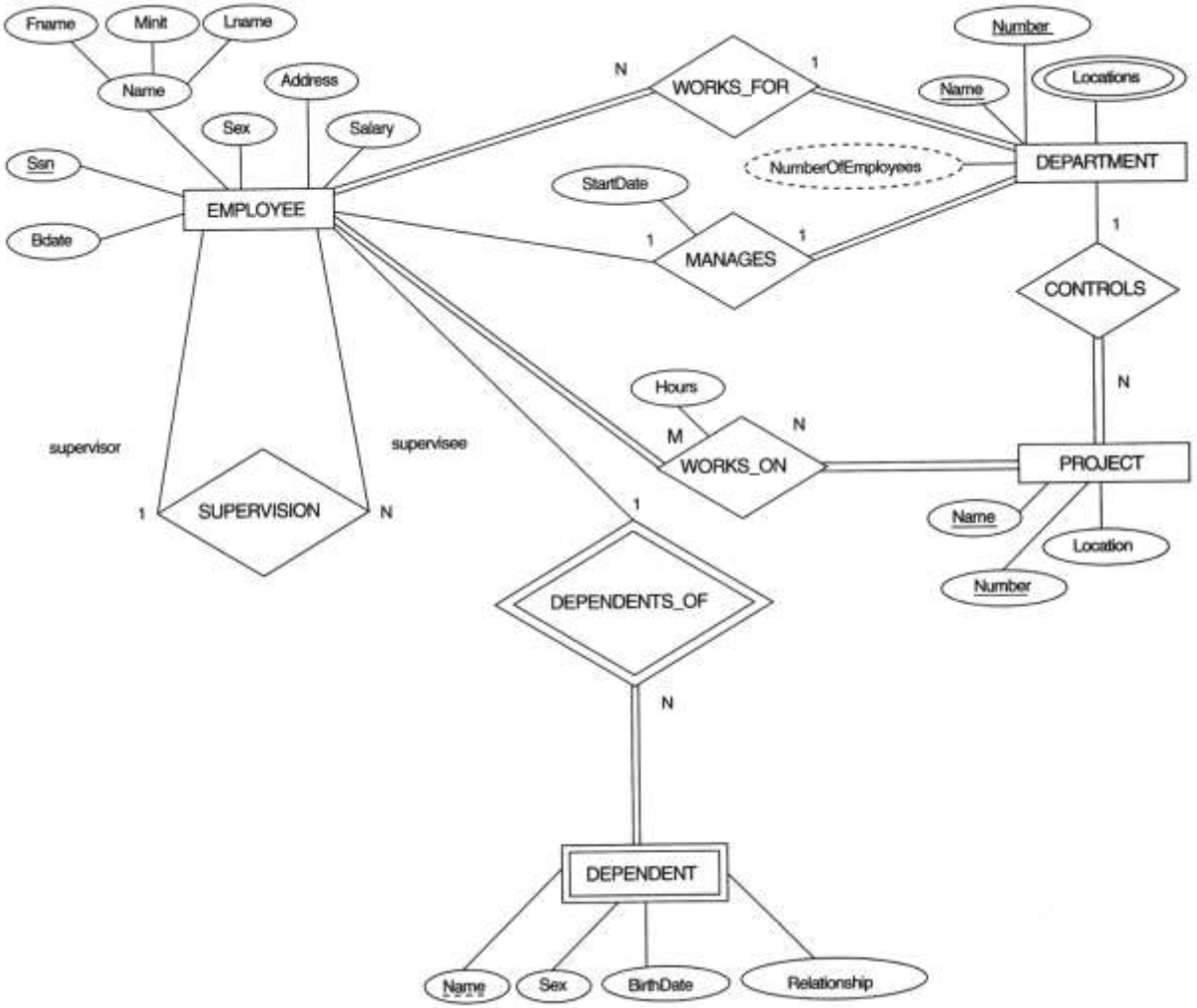


FIGURE 7.2
Result of mapping the COMPANY ER schema into a relational schema.

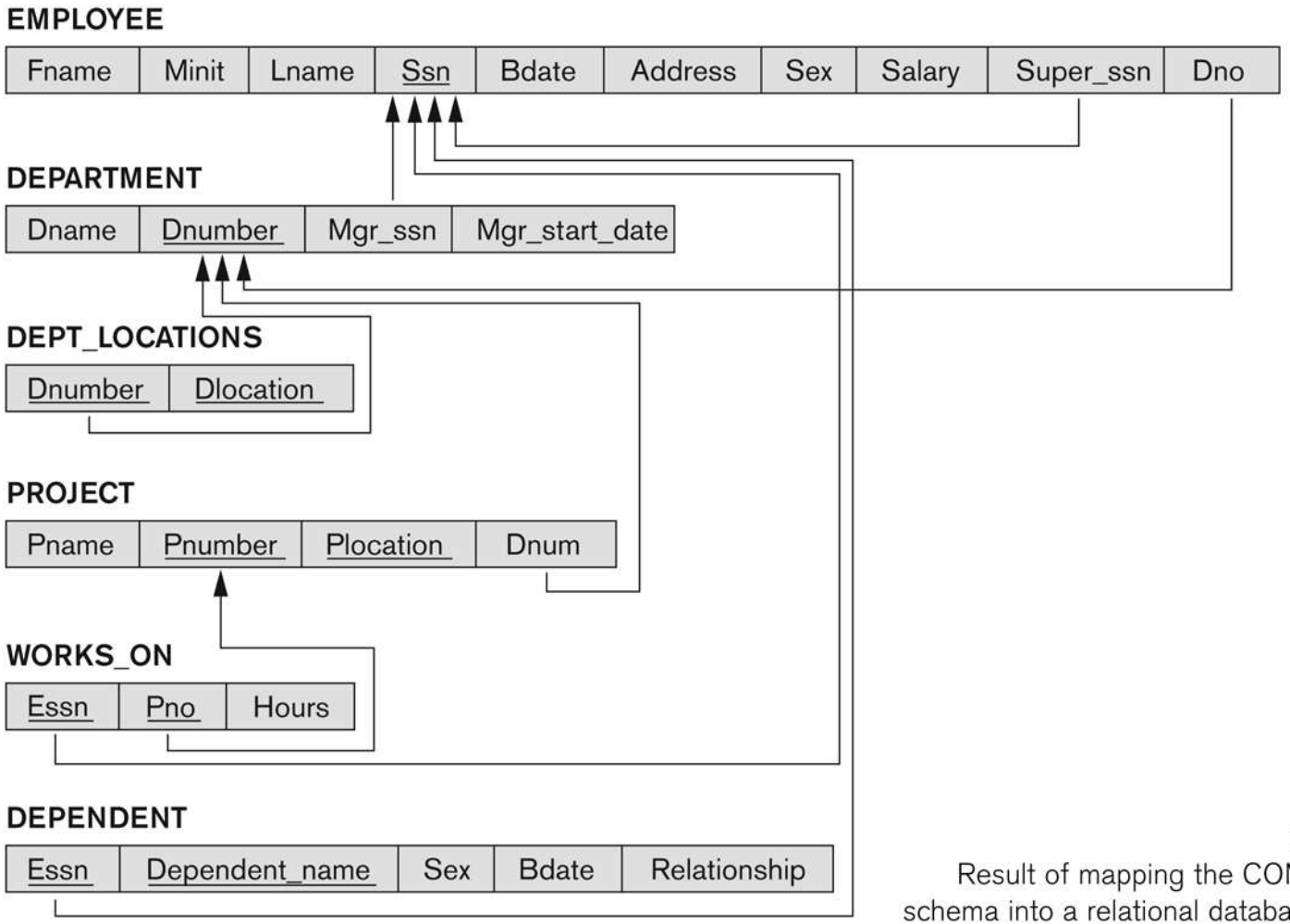
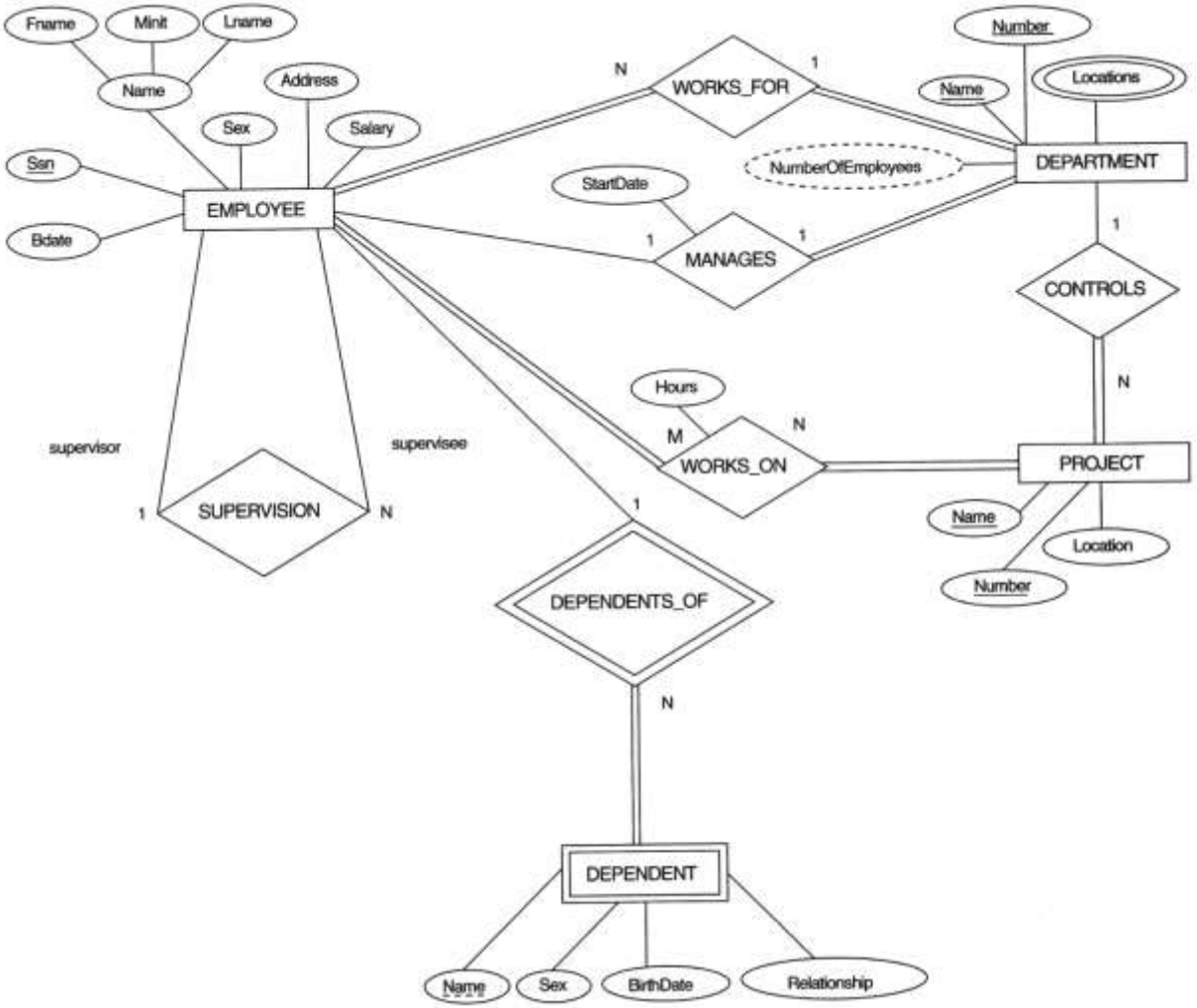


Figure 7.2
Result of mapping the COMPANY ER schema into a relational database schema.

ER-to-Relational Mapping Algorithm

- 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: 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.

FIGURE 7.1
The ER conceptual schema diagram for the COMPANY database.



(a)

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary

DEPARTMENT

Dname	Dnumber

PROJECT

Pname	Pnumber	Plocation

ER-to-Relational Mapping Algorithm (contd.)

- **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** & 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.
- **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.

FIGURE 7.1
The ER conceptual schema diagram for the COMPANY database.

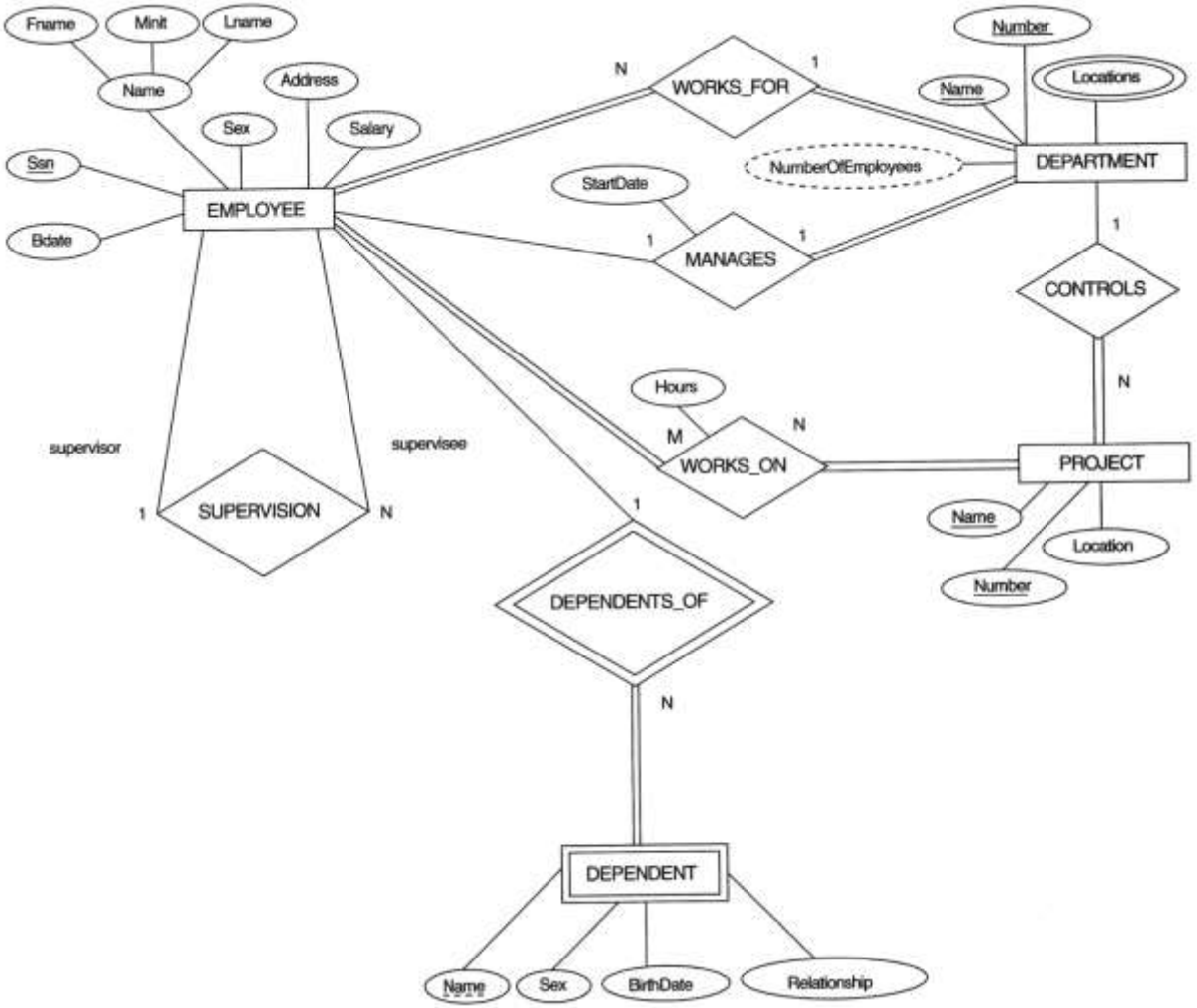


FIGURE 7.2
Result of mapping the COMPANY ER schema into a relational schema.

PK of weak will be the combination of the partial key and the FK of owner

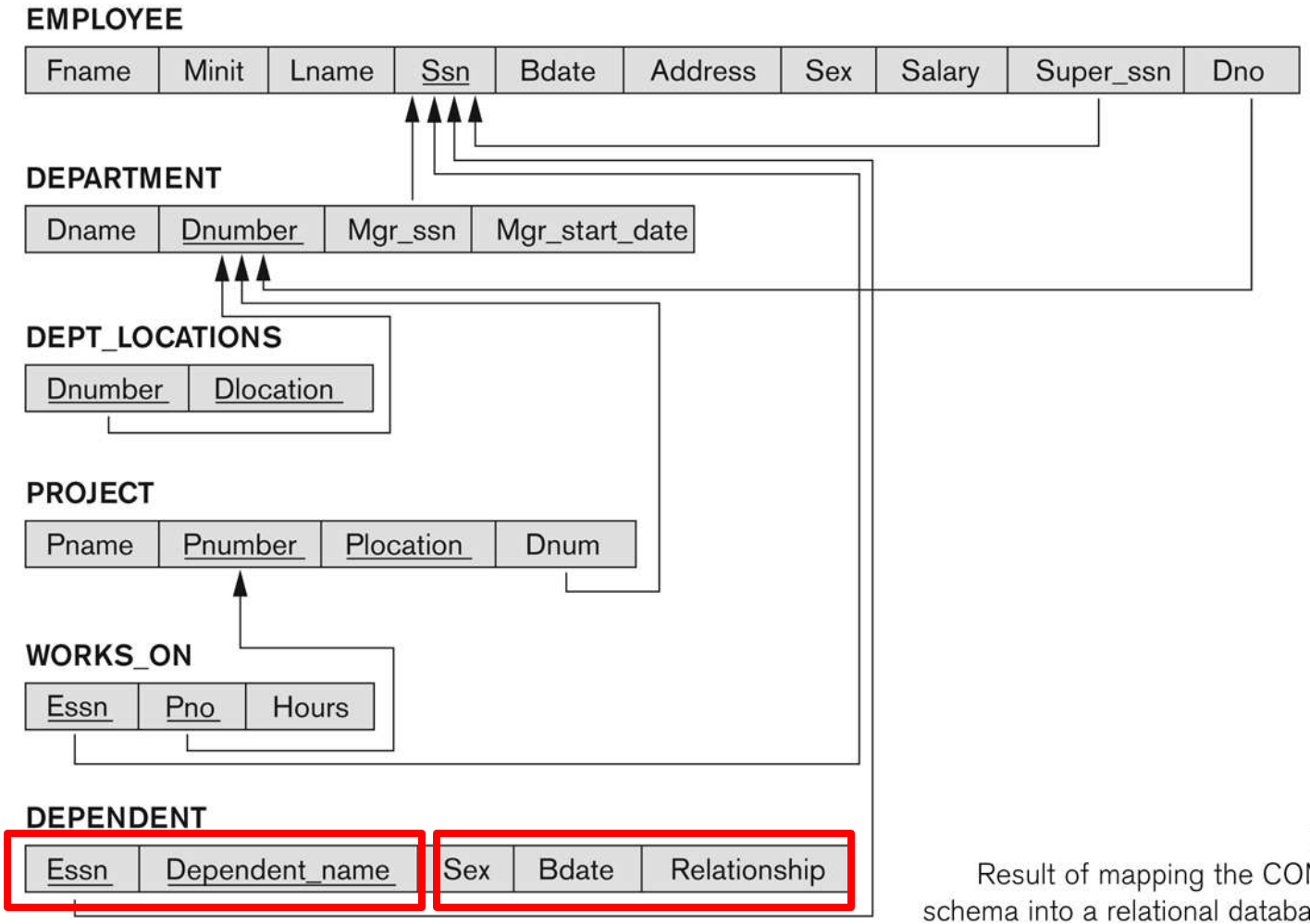
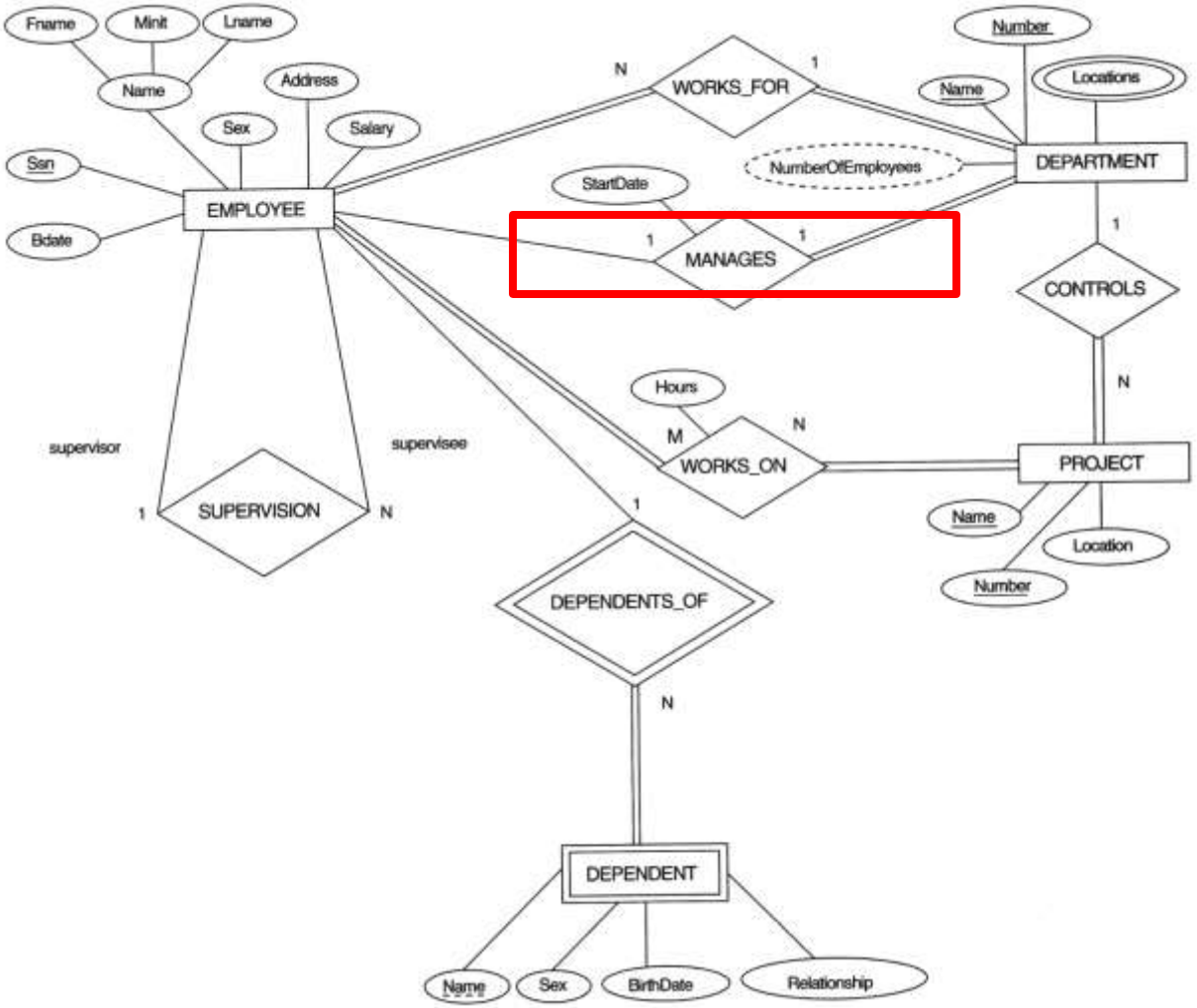


Figure 7.2
Result of mapping the COMPANY ER schema into a relational database schema.

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 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-say 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.
     - 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.
  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 cross-referencing the primary keys of the two relations S and T representing the entity types.

FIGURE 7.1
The ER conceptual schema diagram for the COMPANY database.



Option 1: **It is better to choose an entity type with total participation**

- EMP

SSN	…..	DNO	StartDate
1234		5	1-1-2000
2345		Null	Null
…	…	Null	Null
9898	….	1	1-1-2005
…	…	Null	Null

DEPT

DNO	Dname
1	HR
5	Sales

- OR

SSN	…..
1234	
2345	
…	…
9898	

DNO	Dname	MSSN	StartDate
1	HR	9898	1-1-2005
5	Sales	1234	1-1-2000

Option 2: When both participations are total

- Accounts

Username	Passwrod

STUD

ID	Name

ID	Name	Username	Passwrod

Cross-reference or relationship relation option

- EMP

SSN	…..
1234	
2345	
…	…
9898	….
…	…

DEPT

DNO	Dname
1	HR
5	Sales

- DEPTMANAGER

SSN	DNO	StartDate
1234	1	1-1-2000
9898	5	1-1-2005

FIGURE 7.1
The ER conceptual schema diagram for the COMPANY database.

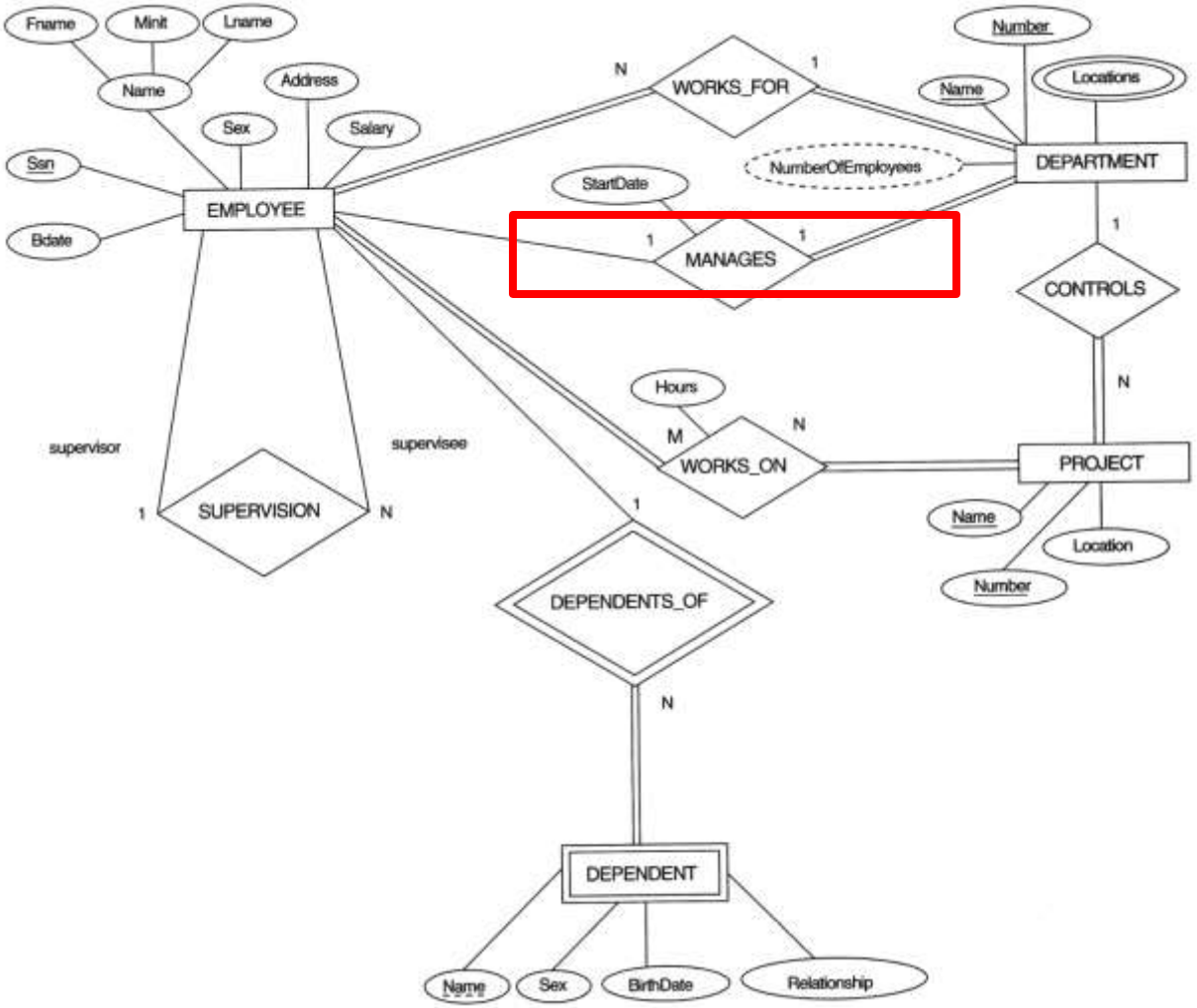
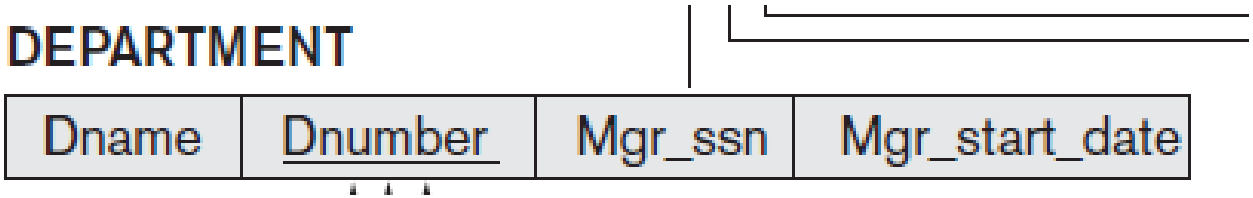


FIGURE 7.2
Result of mapping the COMPANY ER schema into a relational schema.



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

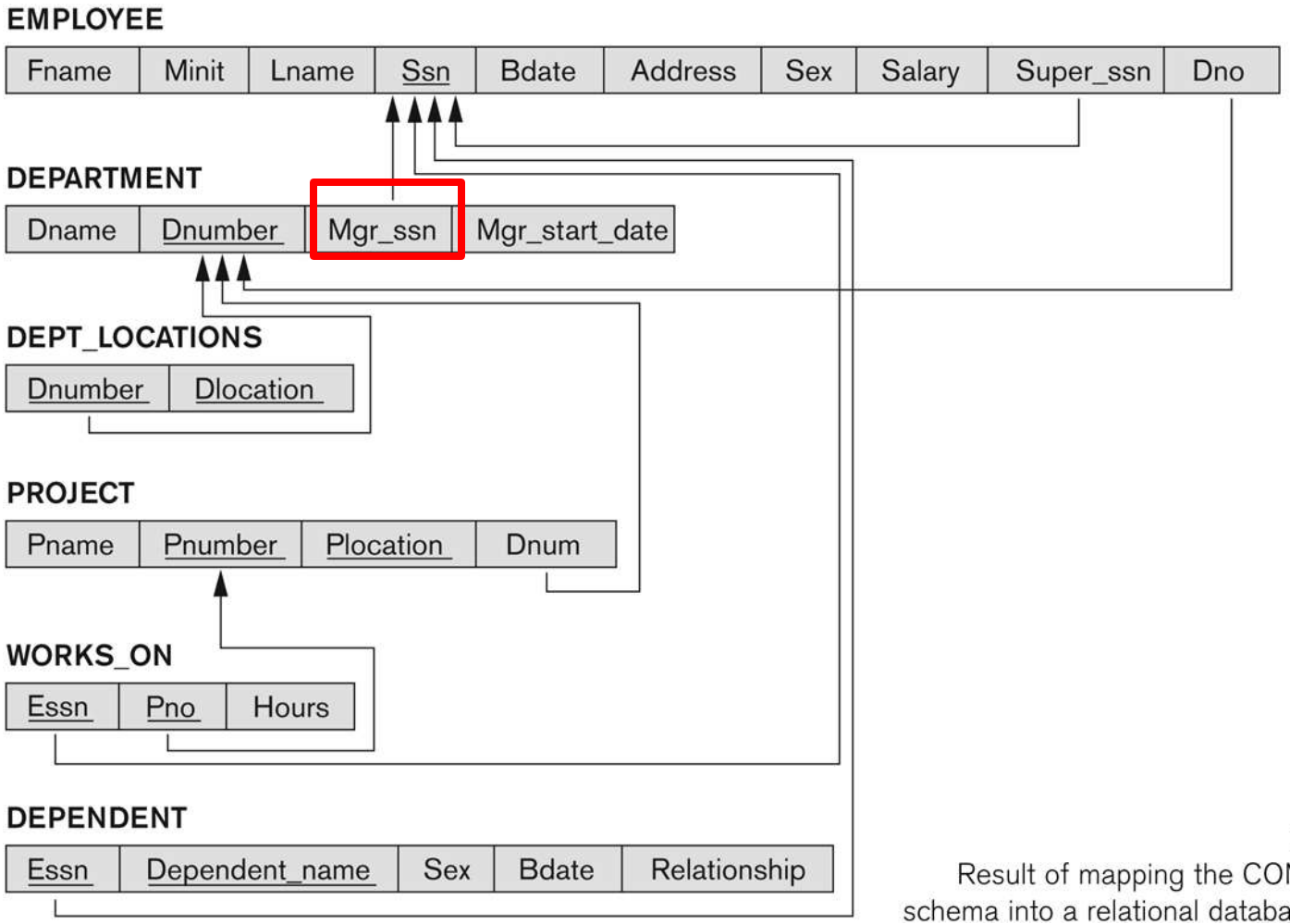


Figure 7.2
Result of mapping the COMPANY ER schema into a relational database schema.

ER-to-Relational Mapping Algorithm (contd.)

- 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 we include the primary key DNUMBER of the DEPARTMENT relation as foreign key in the EMPLOYEE relation and call it DNO.

FIGURE 7.1
The ER conceptual schema diagram for the COMPANY database.

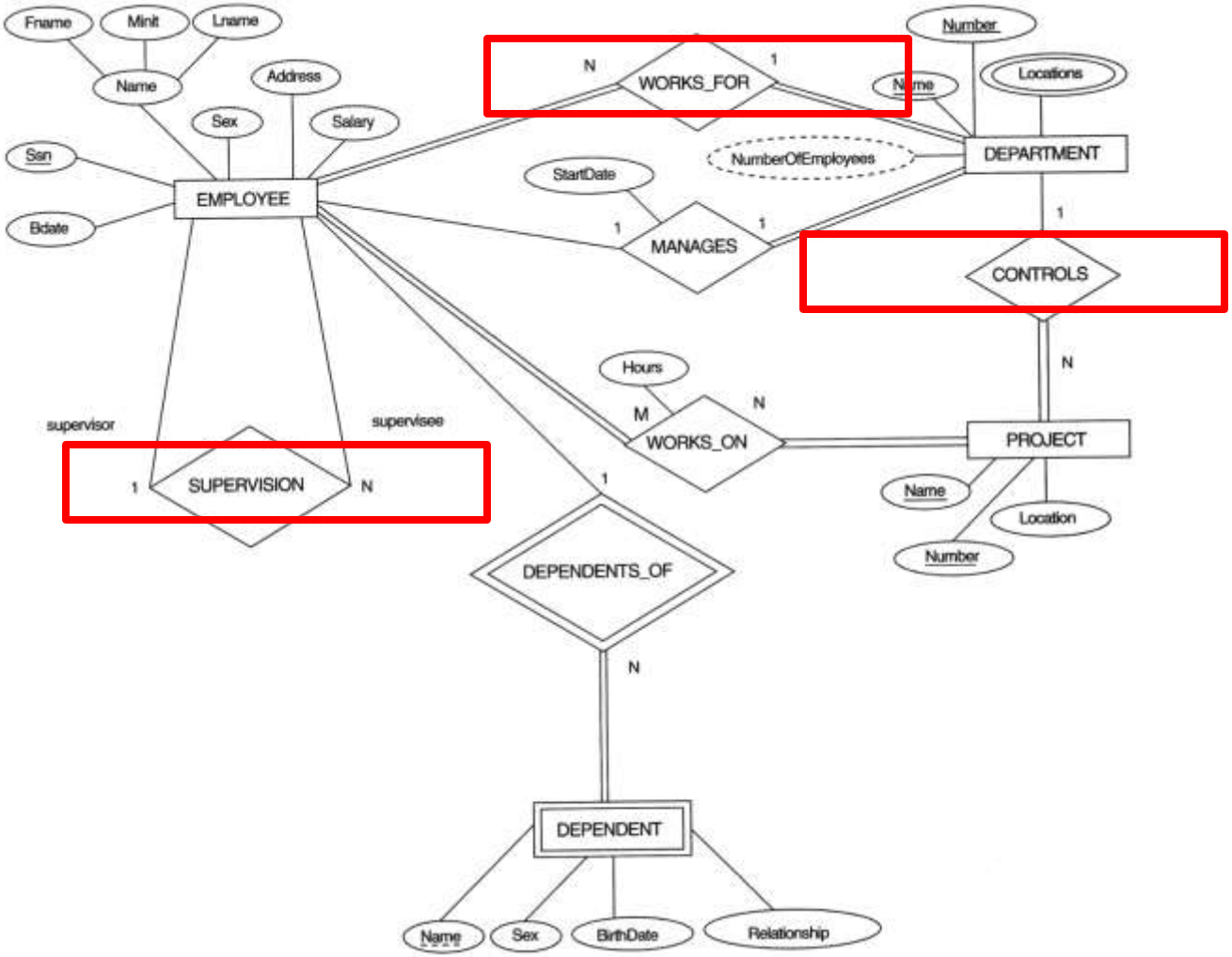


FIGURE 7.2
Result of mapping the COMPANY ER schema into a relational schema.

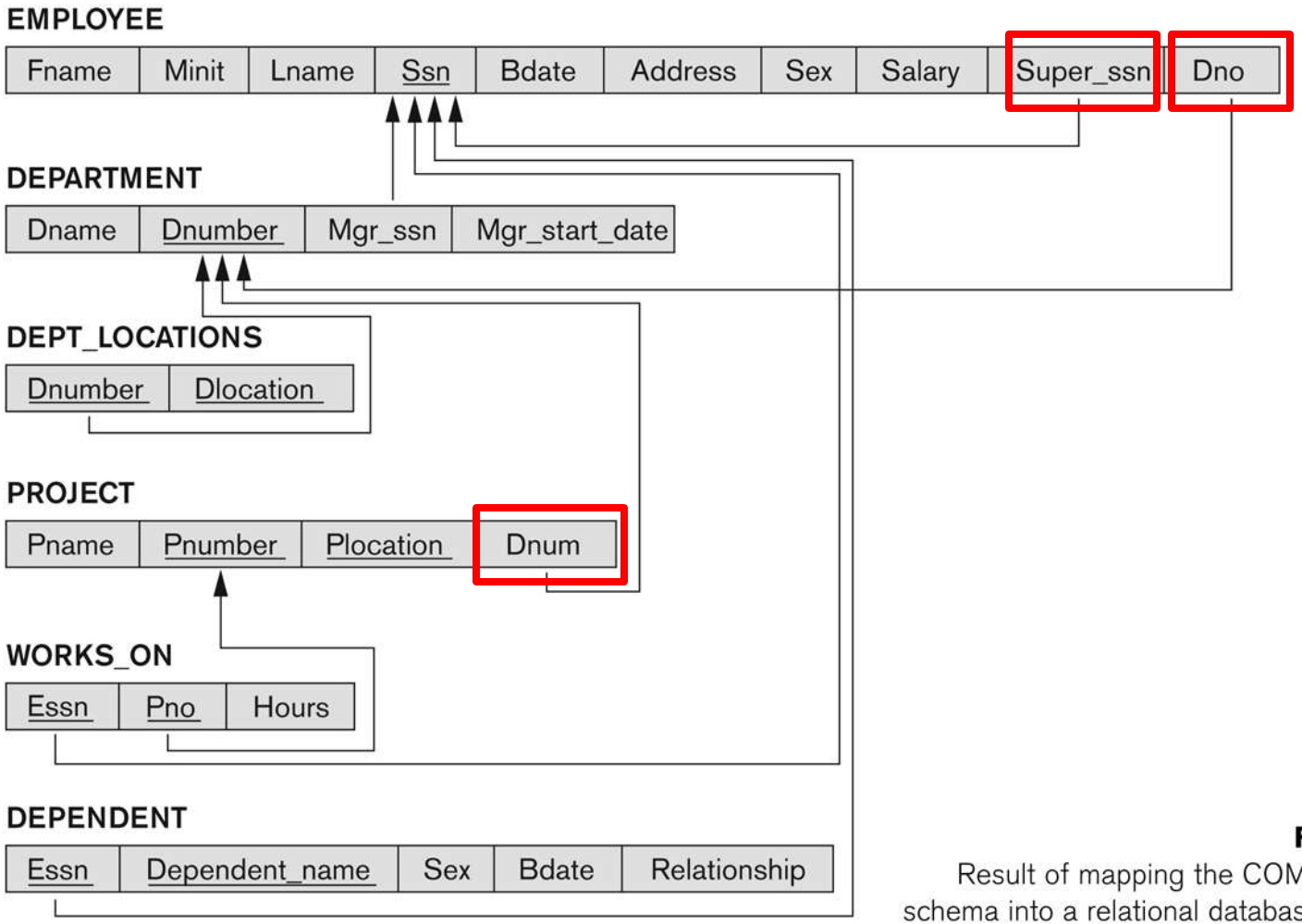


Figure 7.2
Result of mapping the COMPANY ER schema into a relational database schema.

ER-to-Relational Mapping Algorithm (contd.)

- **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.
- 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}.

FIGURE 7.1
The ER conceptual schema diagram for the COMPANY database.

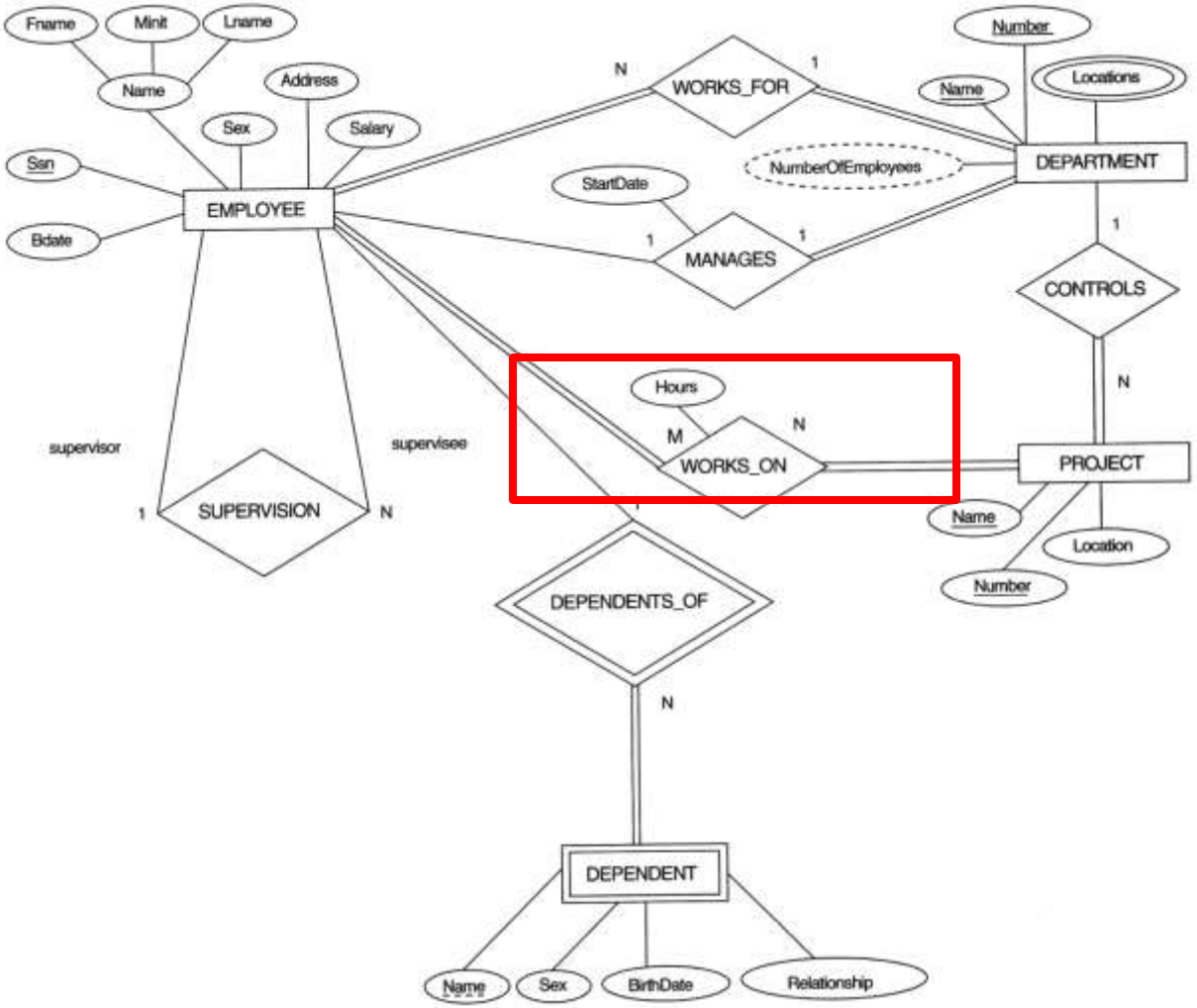


FIGURE 7.2
Result of mapping the COMPANY ER schema into a relational schema.

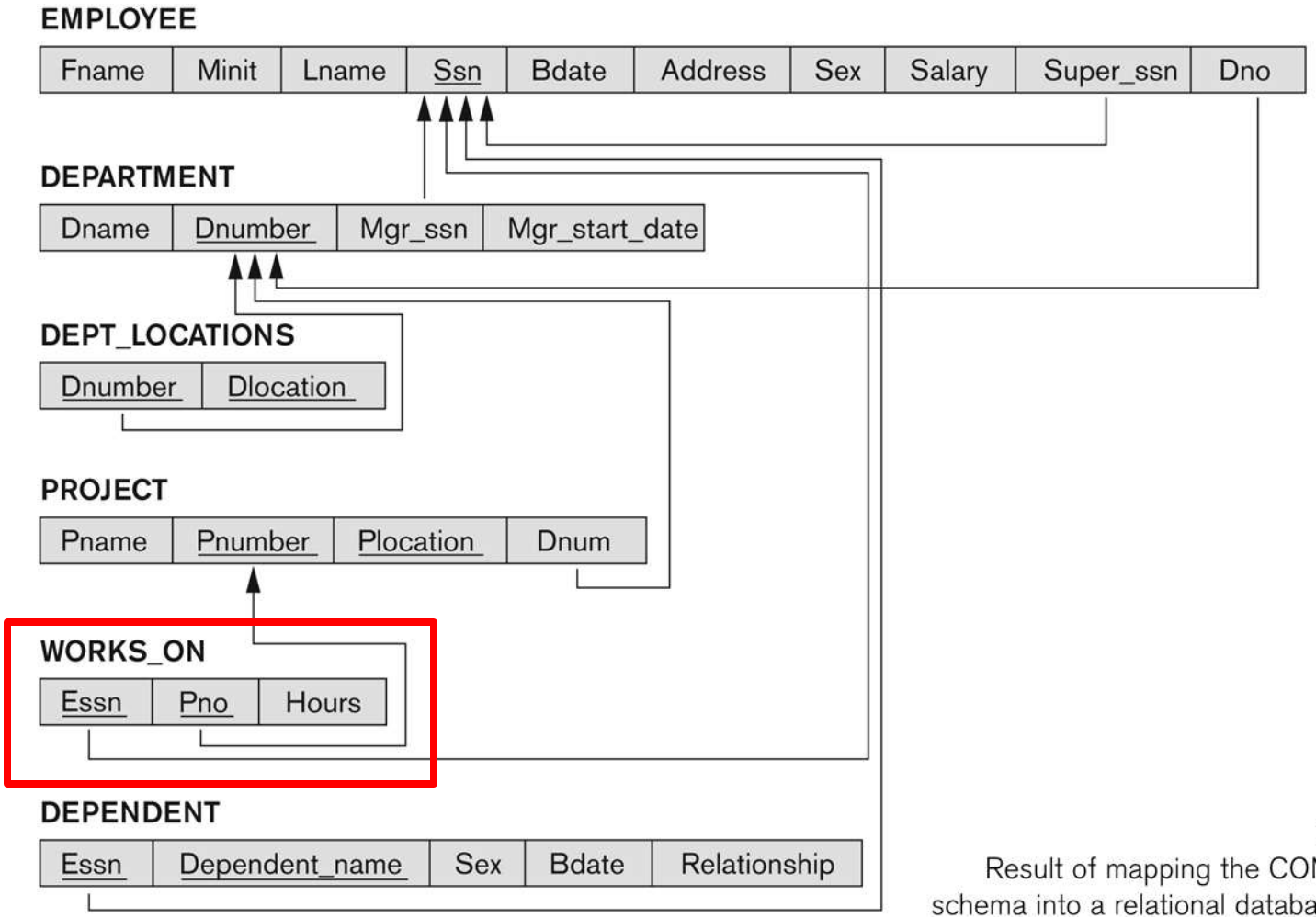


Figure 7.2
Result of mapping the COMPANY ER schema into a relational database schema.

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.
- **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}.

FIGURE 7.1
The ER conceptual schema diagram for the COMPANY database.

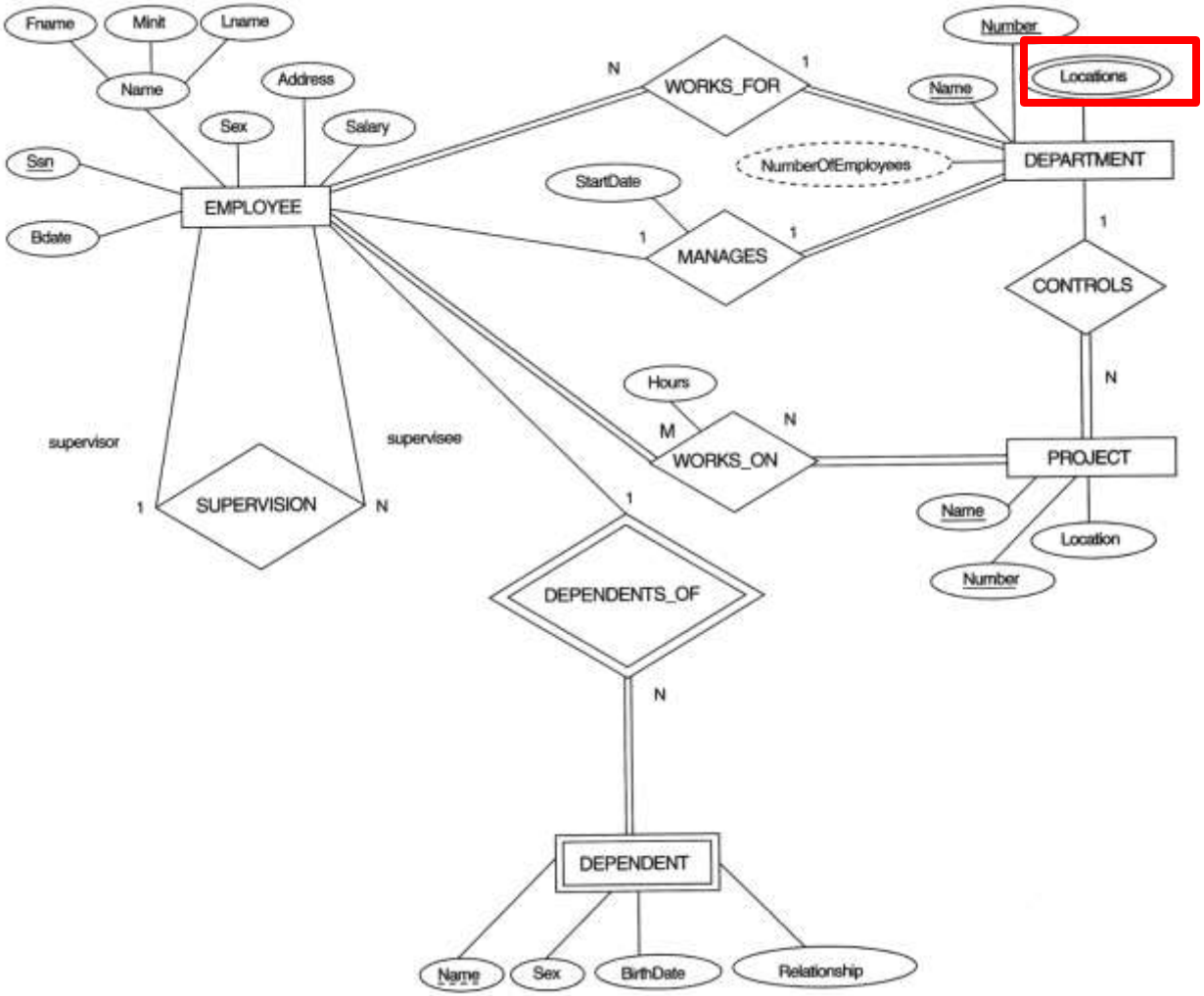


FIGURE 7.2
Result of mapping the COMPANY ER schema into a relational schema.

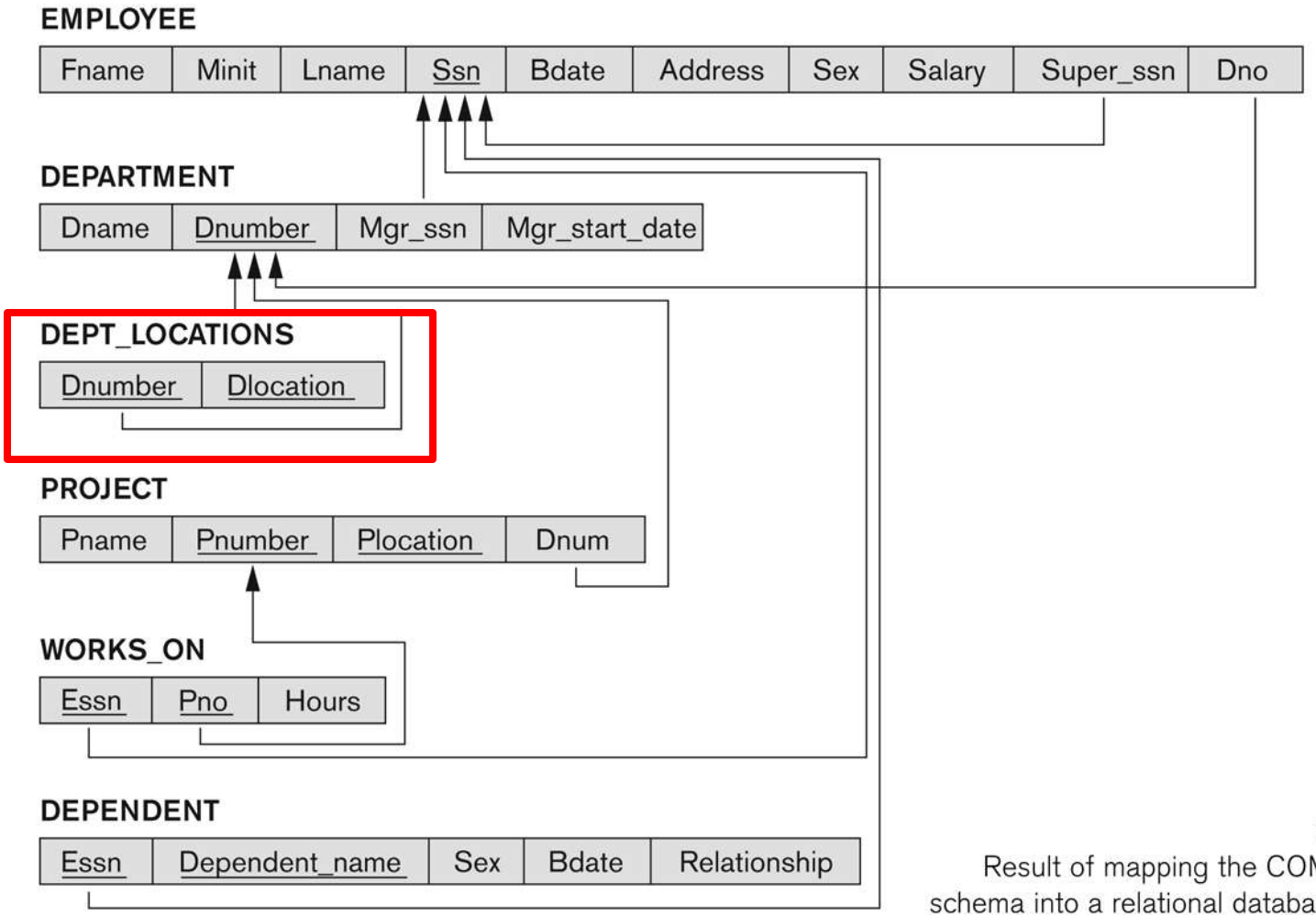


Figure 7.2
Result of mapping the COMPANY ER schema into a relational database schema.

Summary of Mapping constructs and constraints

Table 7.1 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
Key attribute	Primary (or secondary) key

Chapter Summary

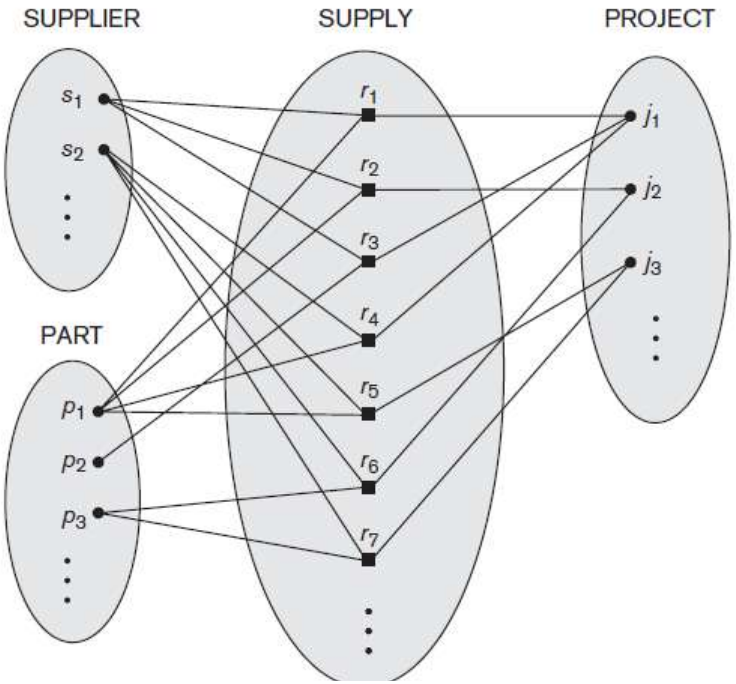
- **ER-to-Relational Mapping Algorithm**
  - Step 1: Mapping of Regular Entity Types
  - Step 2: Mapping of Weak Entity Types
  - Step 3: Mapping of Binary 1:1 Relation Types
  - Step 4: Mapping of Binary 1:N Relationship Types.
  - Step 5: Mapping of Binary M:N Relationship Types.
  - Step 6: Mapping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

Relationships of Higher Degree

- Relationship types of degree 2 are called **binary**
- Relationship types of degree 3 are called **ternary** and of degree n are called n-ary
- In general, an n-ary relationship is not equivalent to n binary relationships
- Constraints are harder to specify for higher-degree relationships (n > 2) than for binary relationships

Discussion of n-ary relationships (n > 2)

- In general, **3 binary relationships can represent different information than a single ternary relationship** (see Figure 3.17a and b on next slide)
- If needed, the binary and n-ary relationships can all be included in the schema design (see Figure 3.17a and b, where all relationships convey different meanings)
- In some cases, **a ternary relationship can be represented as a weak entity if the data model allows a weak entity type to have multiple identifying relationships** (and hence multiple owner entity types) (see Figure 3.17c)
    - **Some database design tools** are based on variations of the ER model that **permit only binary relationships**



Example of a ternary relationship

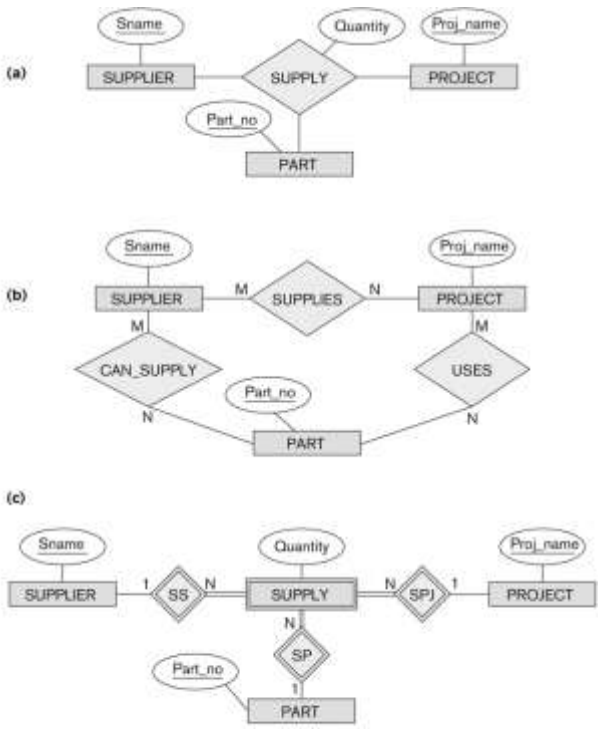


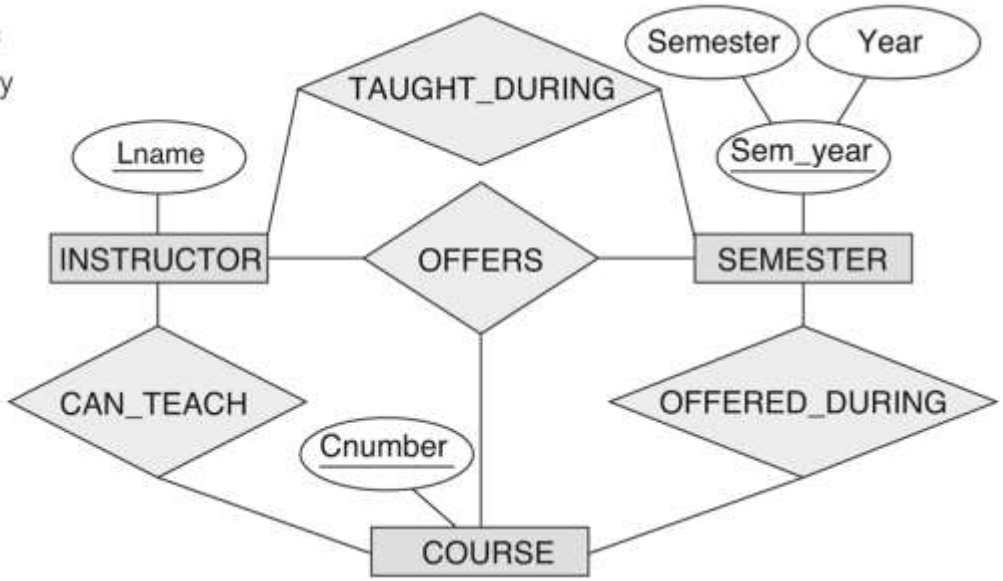
Figure 3.17
Ternary relationship types. (a) The SUPPLY relationship. (b) Three binary relationships not equivalent to SUPPLY. (c) SUPPLY represented as a weak entity type.

Discussion of n-ary relationships (n > 2)

- If a particular binary relationship can be derived from a higher-degree relationship at all times, then it is redundant
- For example, the TAUGHT_DURING binary relationship in Figure 3.18 (see next slide) can be derived from the ternary relationship OFFERS (based on the meaning of the relationships)
- Although in general three binary relationships *cannot replace a ternary relationship,* they may do so under certain *additional constraints. In our example, if the* CAN_TEACH relationship is 1:1 (an instructor can teach one course, and a course can be taught by only one instructor), then the ternary relationship OFFERS can be left out because it can be inferred from the three binary relationships CAN_TEACH, TAUGHT_DURING, and OFFERED_DURING.
- The schema designer must analyze the meaning of each specific situation to decide which of the binary and ternary relationship types are needed.

Another example of a ternary relationship

Figure 3.18
Another example of ternary versus binary relationship types.



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.
- **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}

FIGURE 4.11
Ternary relationship types. (a) The SUPPLY relationship.

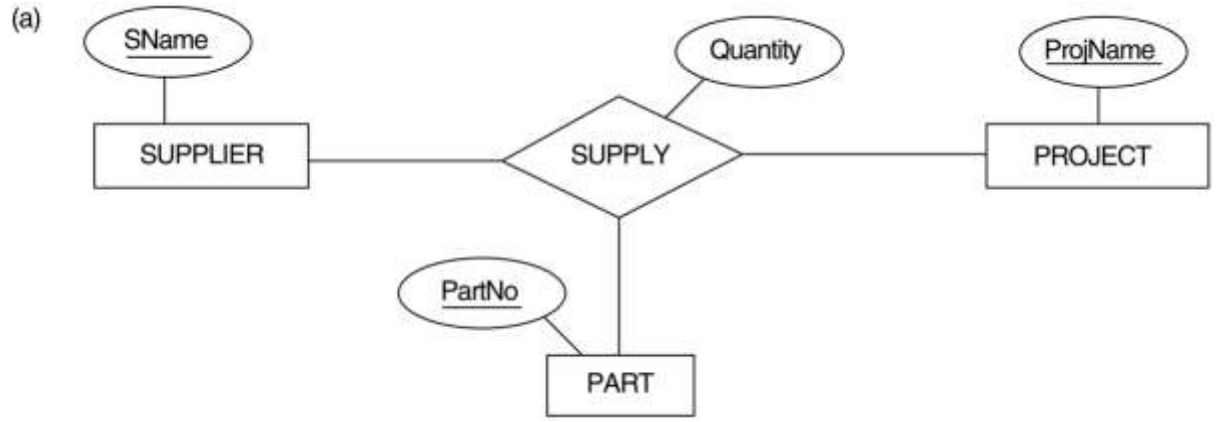


FIGURE 7.3
Mapping the *n*-ary relationship type SUPPLY from Figure 4.11a.