Software Engineering

Database
Data Modeling

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RELATIONSHIP TYPES, RELATION SETS, ROLES, AND STRUCTURAL CONSTRAINTS

Refining the initial design by introducing **relationships**

- The initial design is typically not complete
- Some aspects in the requirements will be represented as **relationships**
- ER model has three main concepts:
  - Entities (and their entity types and entity sets)
  - Attributes (simple, composite, multivalued)
  - Relationships (and their relationship types and relationship sets)
- We introduce relationship concepts next

Relationships and Relationship Types (1)

- A **relationship** **(관계)** relates two or more distinct entities with a specific meaning.
  - E.g.,) EMPLOYEE John Smith *works on* the ProductX PROJECT
  - E.g.,) EMPLOYEE Franklin Wong *manages* the R&D DEPARTMENT
- Relationships of the same type are grouped or typed into a **relationship type** **(관계 유형)**.
  - A set of associations (or relationship set) among entities from *n* entity types
    - E.g.,) WORKS_ON relationship type in which EMPLOYEEs and PROJECTs participate,
    - E.g.,) MANAGES relationship type in which EMPLOYEEs and DEPARTMENTs participate.
- The **degree** of a relationship type is the number of participating entity types.
  - Both MANAGES and WORKS_ON are *binary* relationships.

Degree of a Relationship Type

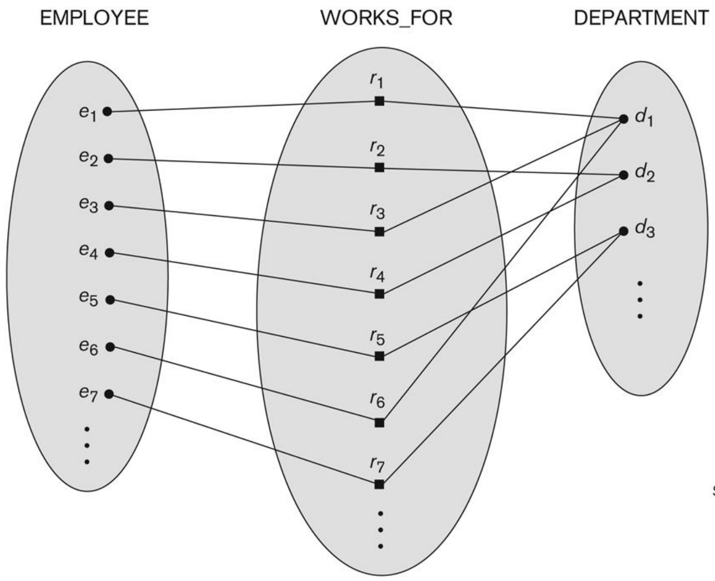


Figure 3.9
Some instances in the WORKS_FOR relationship set, which represents a relationship type WORKS_FOR between EMPLOYEE and DEPARTMENT.

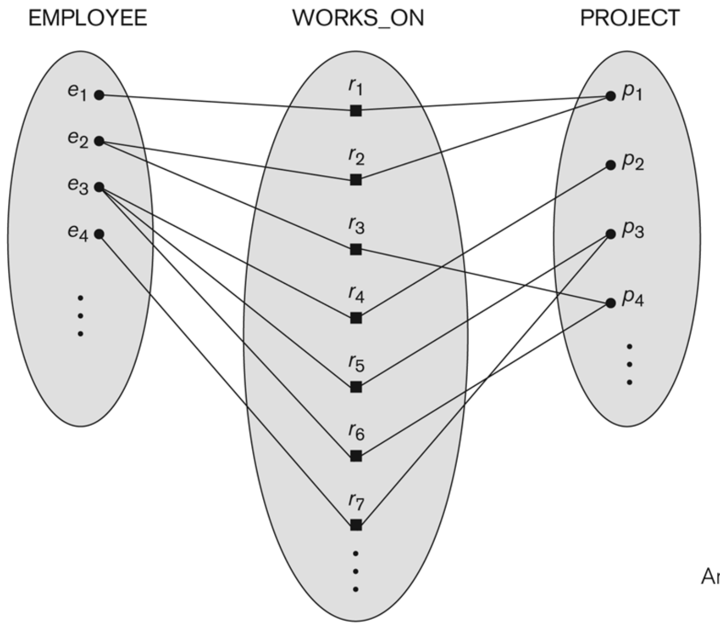


Figure 3.13
An M:N relationship, WORKS_ON.

N:1 WORKS_FOR relationship between EMPLOYEE and DEPARTMENT

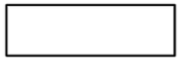
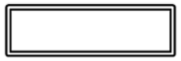
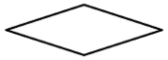
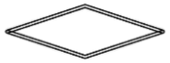
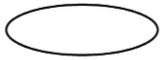
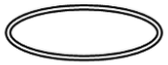
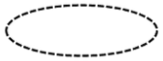
M:N WORKS_ON relationship between EMPLOYEE and PROJECT

Relationship Type vs. Relationship Set (1)

- Relationship Type
  - Schema description of a relationship
  - Identifies the relationship name and the participating entity types
  - Also identifies certain relationship constraints
- Relationship Set
  - The current set of relationship instances represented in the database
  - The current *state* of a relationship type

Relationship Type vs. Relationship Set (2)

- Each instance in the set relates individual participating entities – one from each participating entity type
- In ER diagrams, the *relationship type* is as follows:
  - Diamond-shaped box is used to display a relationship type
  - Connected to the participating entity types via straight lines

Name	Symbol
Entity	
Weak entity	
Relationship	
Weak relationship	
Attribute	
Multi-valued attribute	
Derived attribute	

Refining COMPANY Using Relationships

- Six relationship types are identified
- All are *binary* relationships(degree is two)
- Listed below with their participating entity types:
  - WORKS_FOR (between EMPLOYEE, DEPARTMENT)
  - MANAGES (also between EMPLOYEE, DEPARTMENT)
  - CONTROLS (between DEPARTMENT, PROJECT)
  - WORKS_ON (between EMPLOYEE, PROJECT)
  - SUPERVISION (between EMPLOYEE (as subordinate), EMPLOYEE (as supervisor))
  - DEPENDENTS_OF (between EMPLOYEE, DEPENDENT)

ER DIAGRAM – Relationship Types are:

WORKS_FOR, MANAGES, WORKS_ON, CONTROLS, SUPERVISION, DEPENDENTS_OF

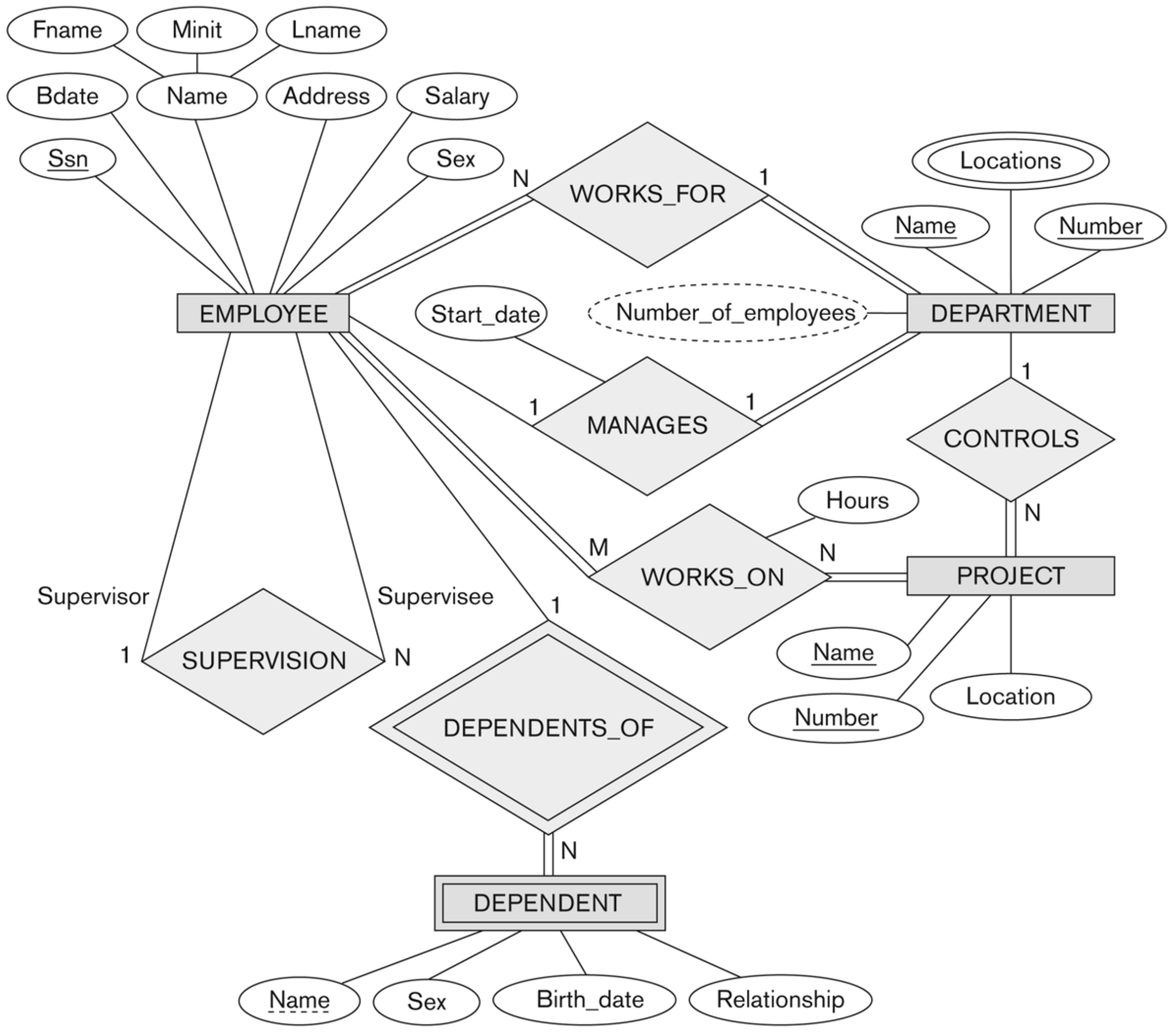


Figure 3.2
An ER schema diagram for the COMPANY database. The diagrammatic notation is introduced gradually throughout this chapter.

Discussion on Relationship Types

- In the refined design, some attributes from the initial entity types are refined into relationships:
  - Manager of DEPARTMENT -> MANAGES
  - Works_on of EMPLOYEE -> WORKS_ON
  - Department of EMPLOYEE -> WORKS_FOR
- In general, more than one relationship type can exist between the same participating entity types
  - MANAGES and WORKS_FOR are distinct relationship types between EMPLOYEE and DEPARTMENT
  - Different meanings and different relationship instances.

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

Many-to-one (N:1) Relationship

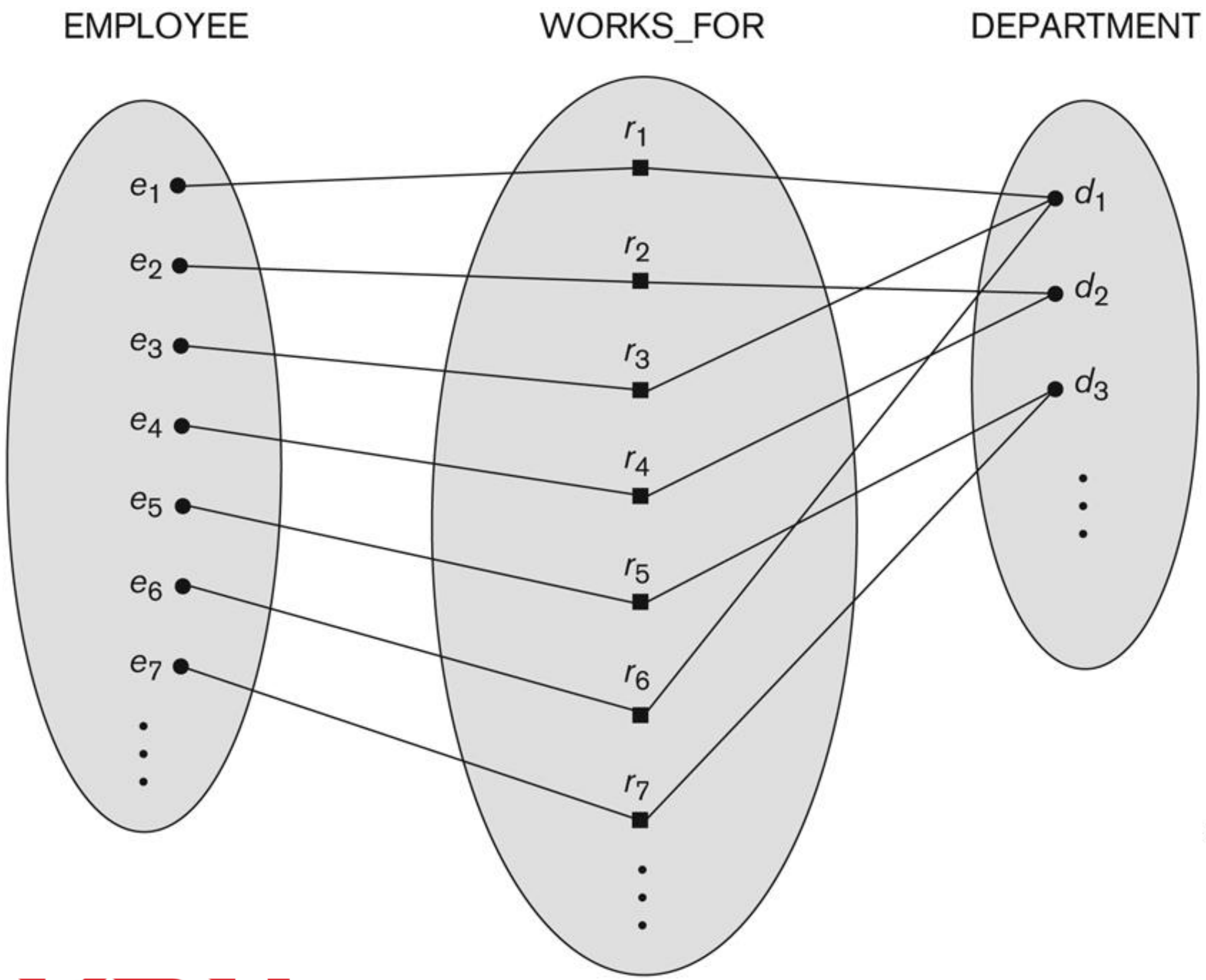


Figure 3.9
Some instances in the WORKS_FOR relationship set, which represents a relationship type WORKS_FOR between EMPLOYEE and DEPARTMENT.

Many-to-many (M:N) Relationship

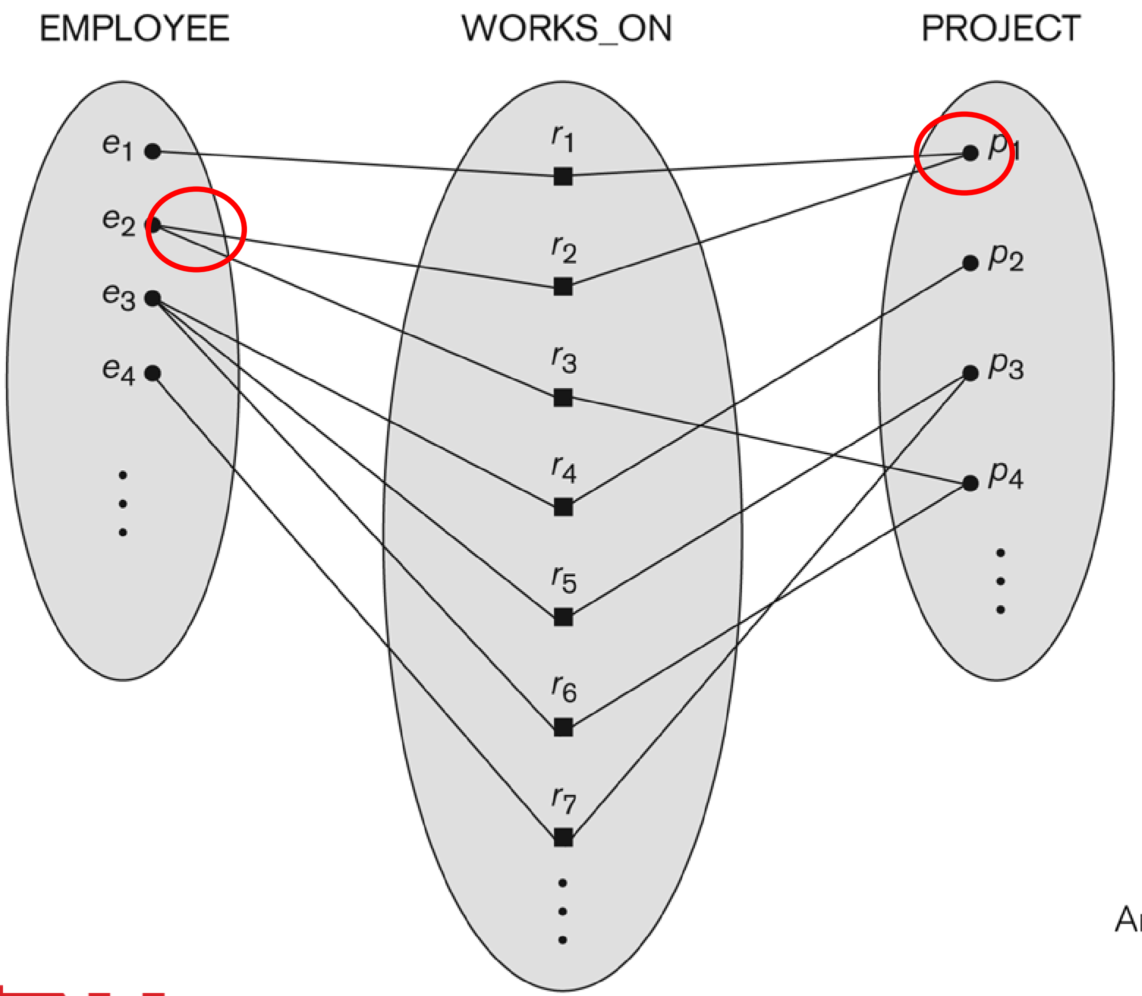


Figure 3.13
An M:N relationship, WORKS_ON.

Recursive Relationship Type

- A relationship type between the same participating entity type in **distinct roles**
- Also called a **self-referencing** relationship type.
  - E.g., SUPERVISION relationship
    - EMPLOYEE participates twice in two distinct roles:
    - supervisor (or boss) role
    - supervisee (or subordinate) role
- Each relationship instance relates two distinct EMPLOYEE
  - One employee in *supervisor* role
  - One employee in *supervisee* role

A Recursive Relationship Supervision

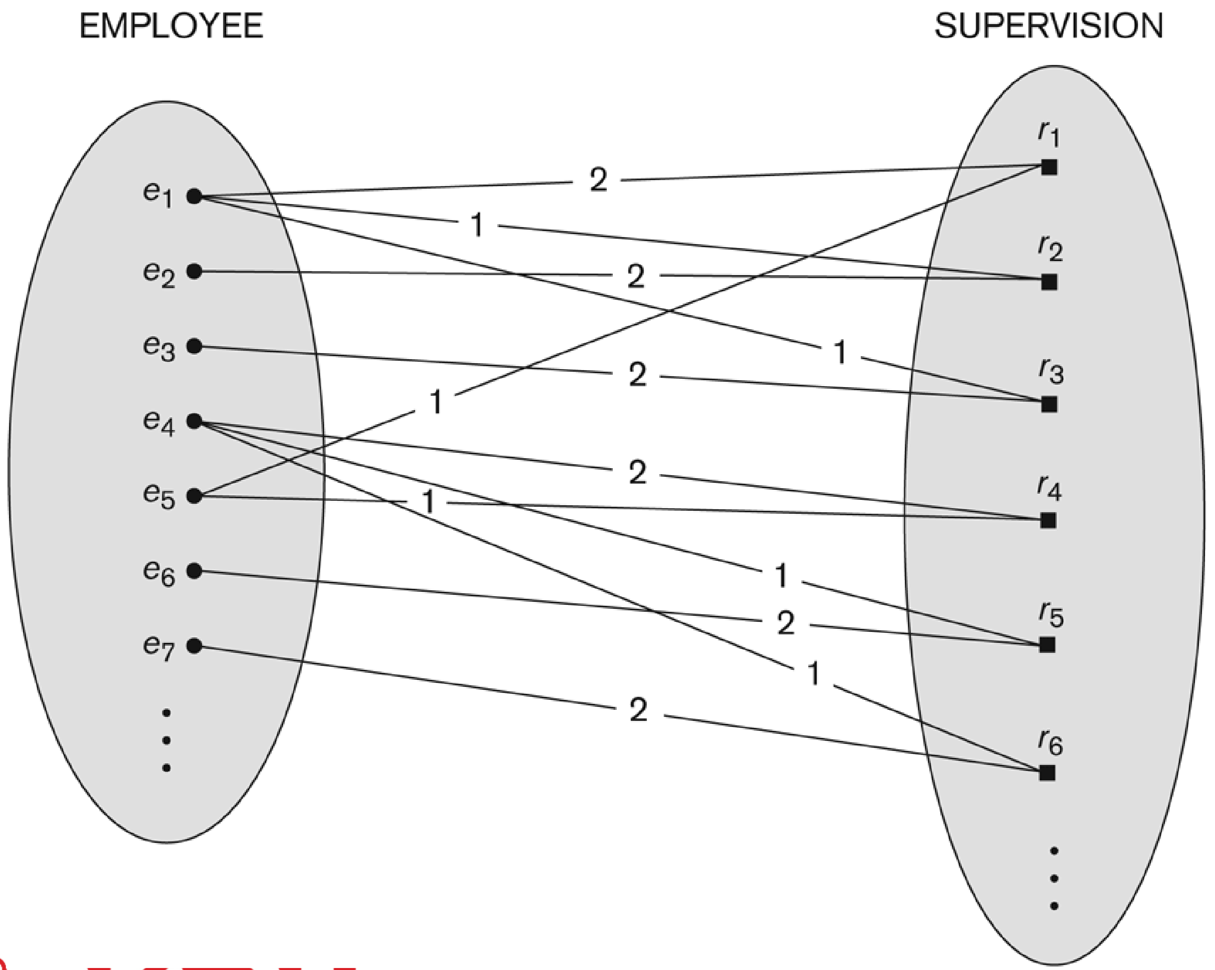


Figure 3.11
A recursive relationship SUPERVISION between EMPLOYEE in the *supervisor* role (1) and EMPLOYEE in the *subordinate* role (2).

Recursive Relationship Type is: SUPERVISION (participation role names are shown)

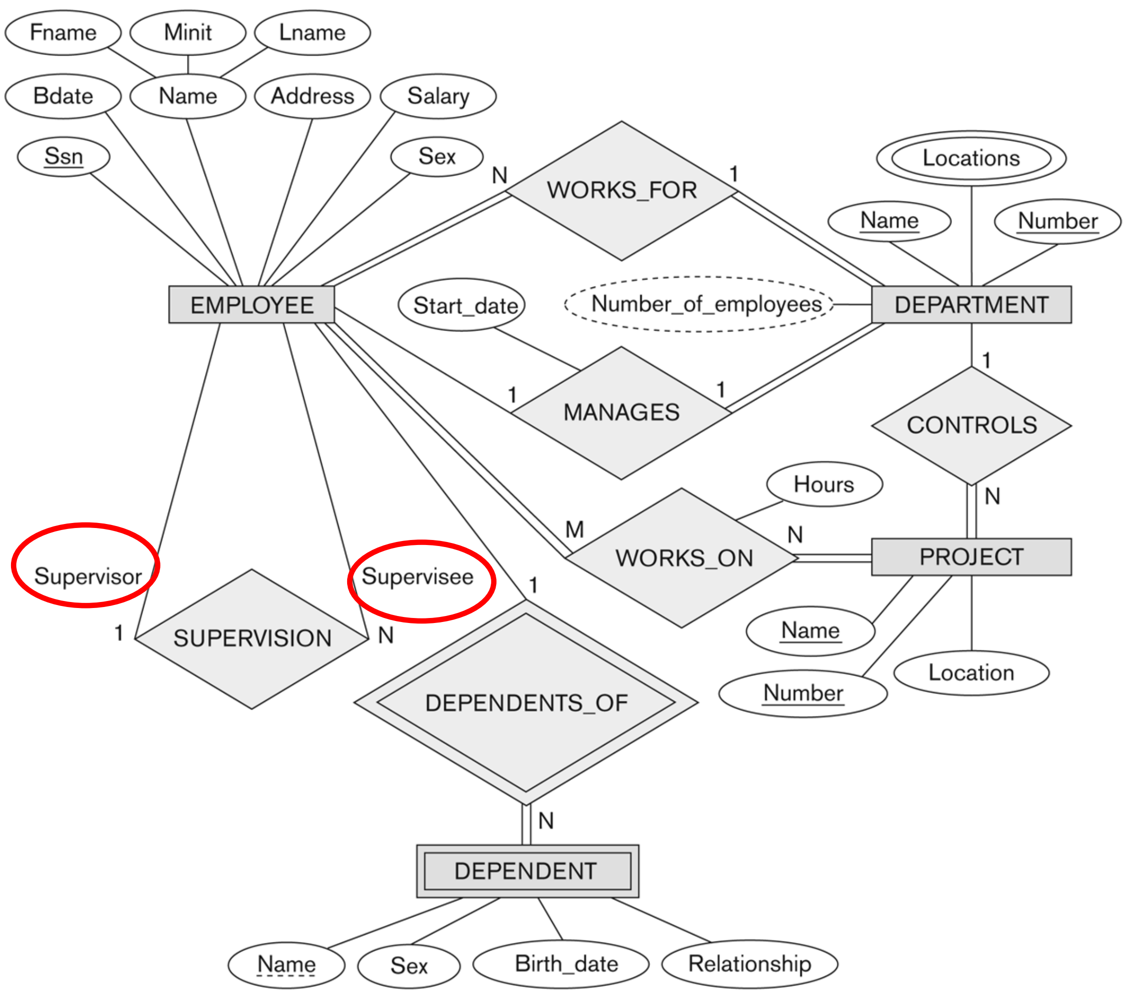


Figure 3.2
An ER schema diagram for the COMPANY database. The diagrammatic notation is introduced gradually throughout this chapter.

Weak Entity Types

- An entity that does not have a key attribute and that is identification-dependent on another entity type.
- A weak entity must participate in an identifying relationship type with an owner or identifying entity type
- Entities are identified by the combination of:
  - A partial key of the weak entity type
  - The particular entity they are related to in the identifying relationship type
- **Example:**
  - A DEPENDENT entity is identified by the dependent's first name, *and* the specific EMPLOYEE
  - DEPENDENT is a *weak entity type*
  - EMPLOYEE is its identifying entity type via the identifying relationship type DEPENDENT_OF

Attributes of Relationship types

- A relationship type can have attributes:
  - E.g., HoursPerWeek of WORKS_ON
    - Hours/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
      - E.g., DEPARTMENT : EMPLOYEE (1:N)'s EmpStartDate

Example Attribute of a Relationship Type: Hours of WORKS_ON

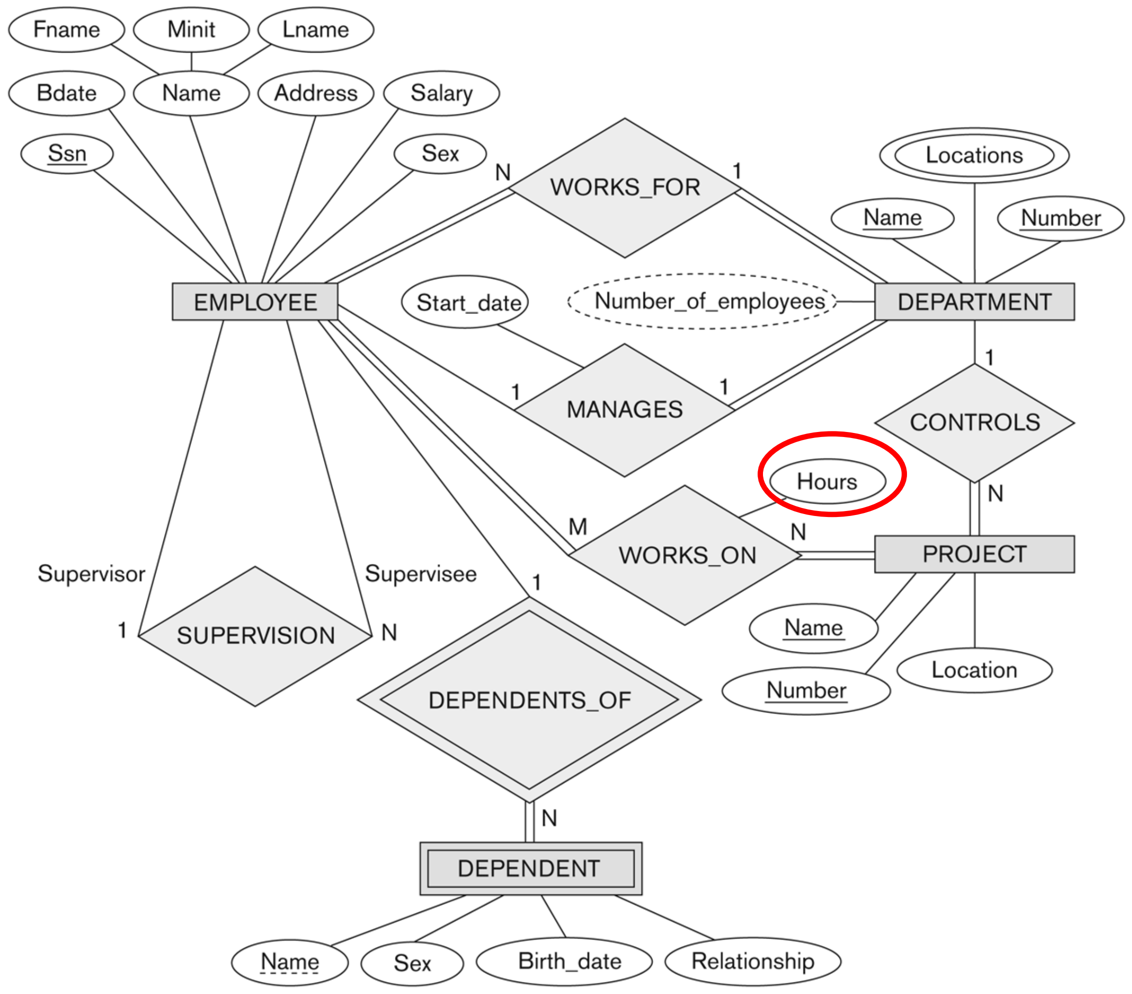


Figure 3.2
An ER schema diagram for the COMPANY database. The diagrammatic notation is introduced gradually throughout this chapter.

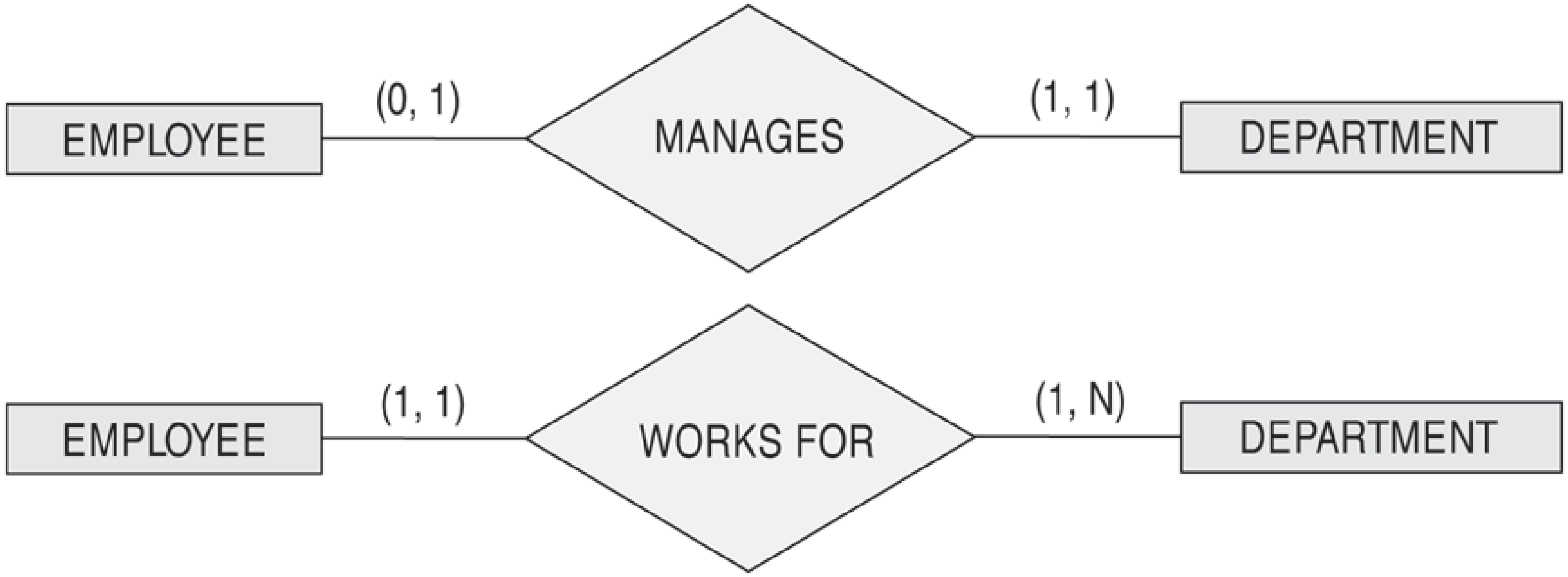
Notation for Constraints on Relationships

- 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.

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
- 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

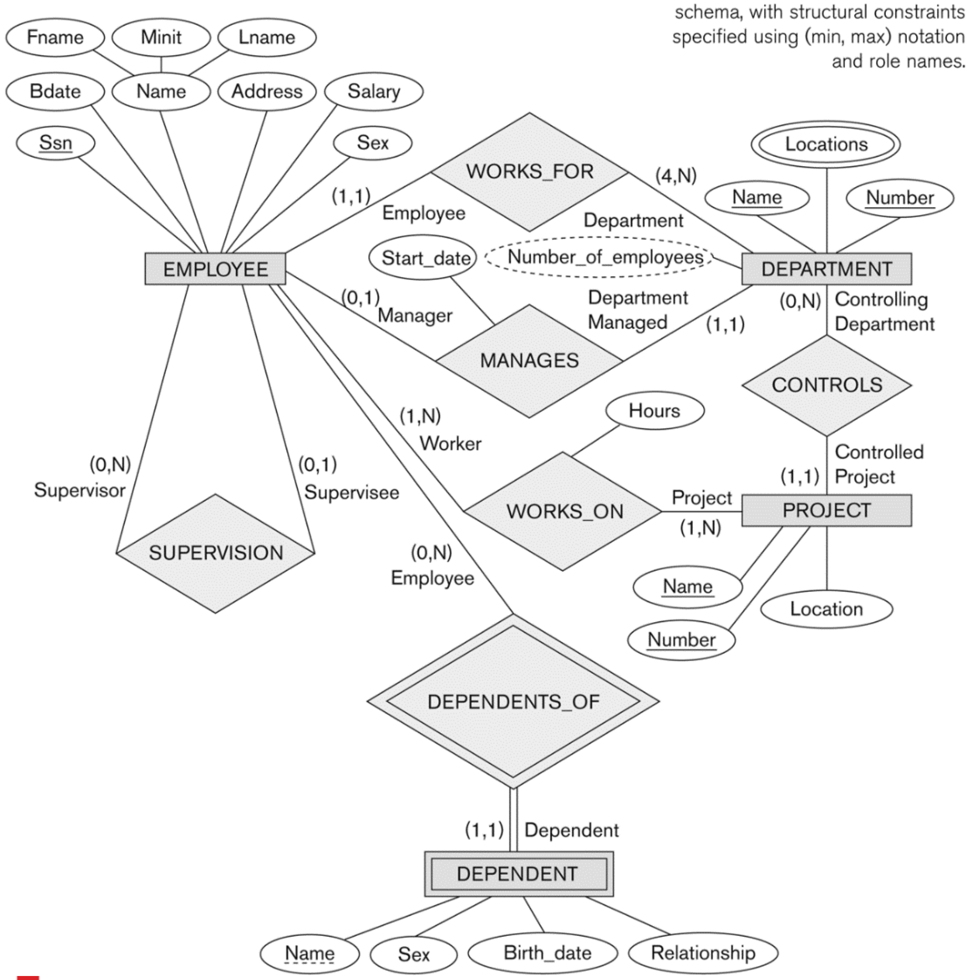


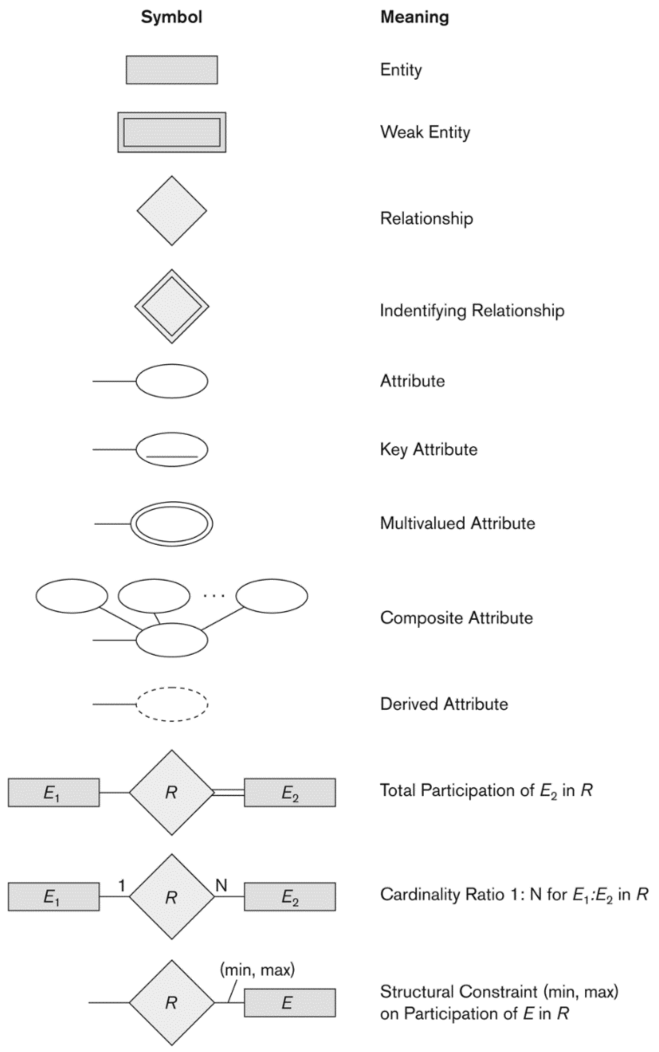
Figure 3.15
ER diagrams for the company schema, with structural constraints specified using (min, max) notation and role names.

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
- Appendix A illustrates some of the alternative notations that have been used
- UML class diagrams is representative of another way of displaying ER concepts that is used in several commercial design tools

Summary of notation for ER diagrams

Figure 3.14
Summary of the notation for ER diagrams.

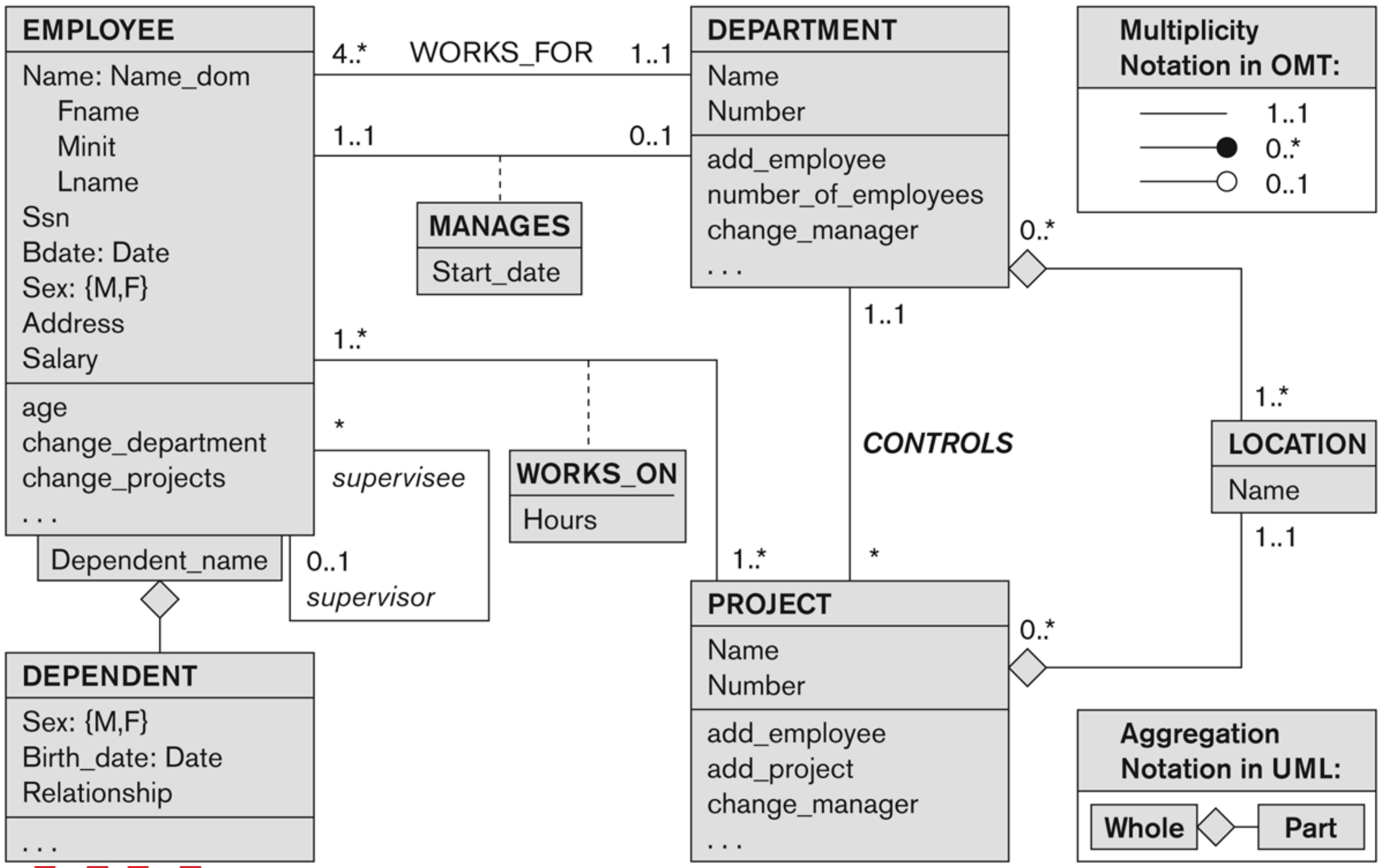

Symbol
Meaning
Entity
Weak Entity
Relationship
Indentifying Relationship
Attribute
Key Attribute
Multivalued Attribute
. . .
Composite Attribute
Derived Attribute
E1
R
E2
Total Participation of E2 in R
E1
1
R
N
E2
Cardinality Ratio 1: N for E1:E2 in R
R
(min, max)
E
Structural Constraint (min, max) on Participation of E in R

UML class diagrams

- Represent classes (similar to entity types) as large rounded boxes with three sections:
  - Top section includes entity type (class) name
  - Second section includes attributes
  - Third section includes class operations (operations are not in basic ER model)
- Relationships (called associations) represented as lines connecting the classes
  - Other UML terminology also differs from ER terminology
- Used in database design and object-oriented software design
- UML has many other types of diagrams for software design

UML class diagram for COMPANY schema

Figure 3.16
The COMPANY conceptual schema in UML class diagram notation.



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

Example of a ternary relationship

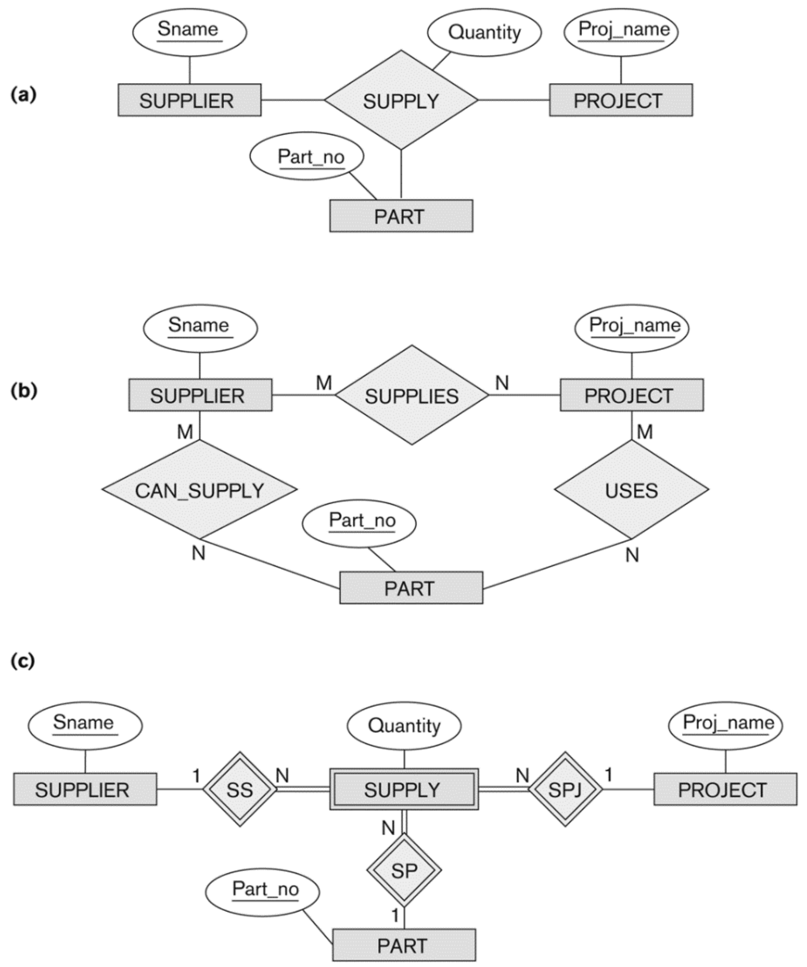


Figure 3.17
Ternary relationship types. (a) The SUPPLY relationship. (b) Three binary relationships not equivalent to SUPPLY. (c) SUPPLY represented as a weak entity type.

Chapter Summary

- ER Model Concepts: Entities, attributes, relationships
- Constraints in the ER model
- Using ER in step-by-step mode conceptual schema design for the COMPANY database
- ER Diagrams - Notation
- Alternative Notations – UML class diagrams, others
- Binary Relationship types and those of higher degree.