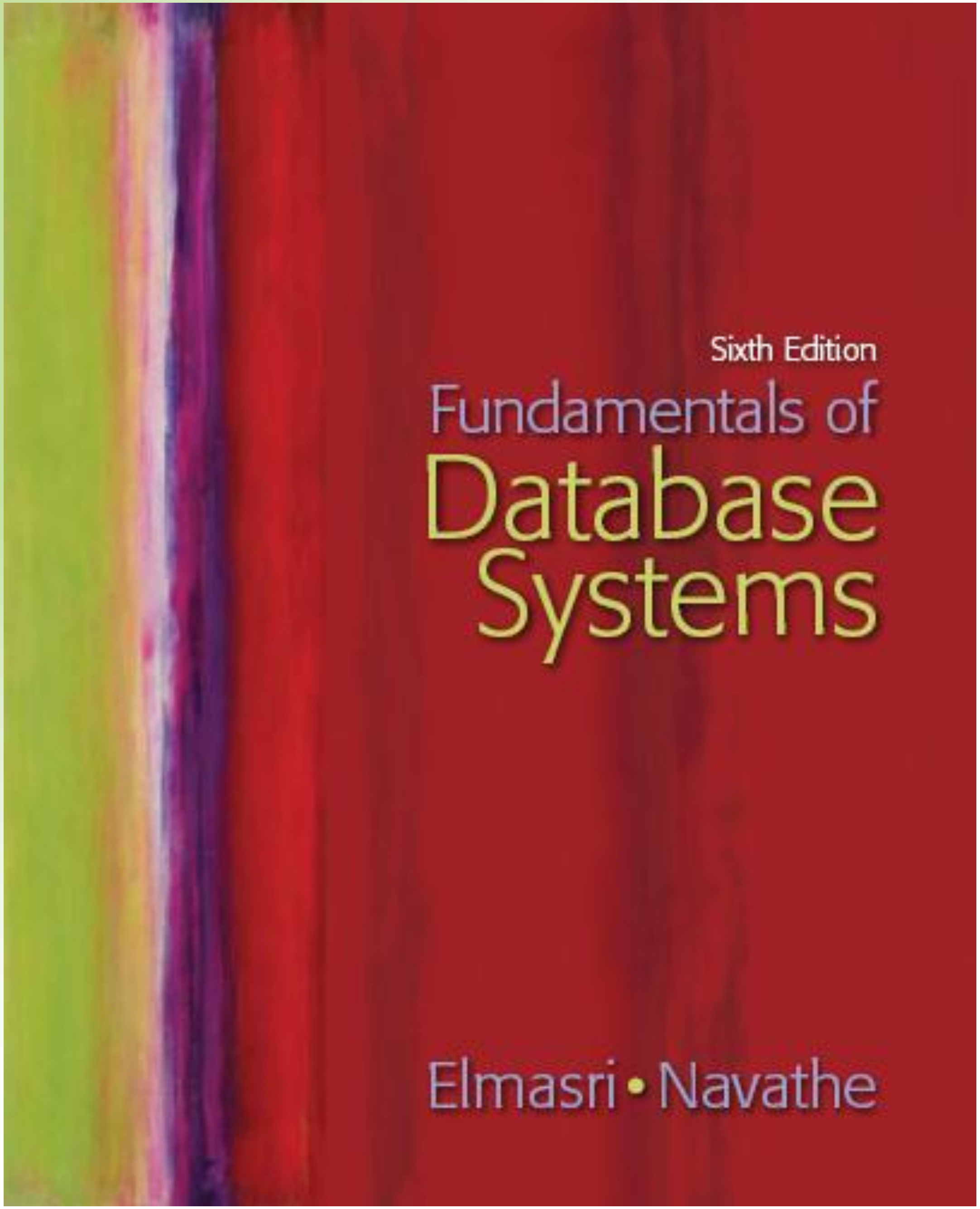
Chapter 7

Data Modeling Using the Entity-Relationship (ER) Model



Sixth Edition

Fundamentals of Database Systems

Elmasri • Navathe

Chapter 7 Outline

- Using High-Level Conceptual Data Models for Database Design
- A Sample Database Application
- Entity Types, Entity Sets, Attributes, and Keys
- Relationship Types, Relationship Sets, Roles, and Structural Constraints
- Weak Entity Types

Chapter 7 Outline (cont'd.)

- Refining the ER Design for the COMPANY Database
- ER Diagrams, Naming Conventions, and Design Issues
- Example of Other Notation: UML Class Diagrams
- Relationship Types of Degree Higher than Two

Data Modeling Using the Entity-Relationship (ER) Model

- **Entity-Relationship (ER) model**
  - Popular high-level conceptual data model
- **ER diagrams**
  - Diagrammatic notation associated with the ER model
- **Unified Modeling Language (UML)**

Using High-Level Conceptual Data Models for Database Design

- **Requirements collection and analysis**
  - Database designers interview prospective database users to understand and document data requirements
  - Result: **data requirements**
  - **Functional requirements** of the application

Using High-Level Conceptual Data Models (cont'd.)

- **Conceptual schema**
  - Conceptual design
  - Description of data requirements
  - Includes detailed descriptions of the entity types, relationships, and constraints
  - Transformed from high-level data model into implementation data model

Using High-Level Conceptual Data Models (cont'd.)

- **Logical design** or **data model mapping**
  - Result is a database schema in implementation data model of DBMS
- **Physical design phase**
  - Internal storage structures, file organizations, indexes, access paths, and physical design parameters for the database files specified

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A Sample Database Application

- COMPANY
  - Employees, departments, and projects
  - Company is organized into departments
  - Department controls a number of projects
  - Employee: store each employee’s name, Social Security number, address, salary, sex (gender), and birth date
  - Keep track of the dependents of each employee

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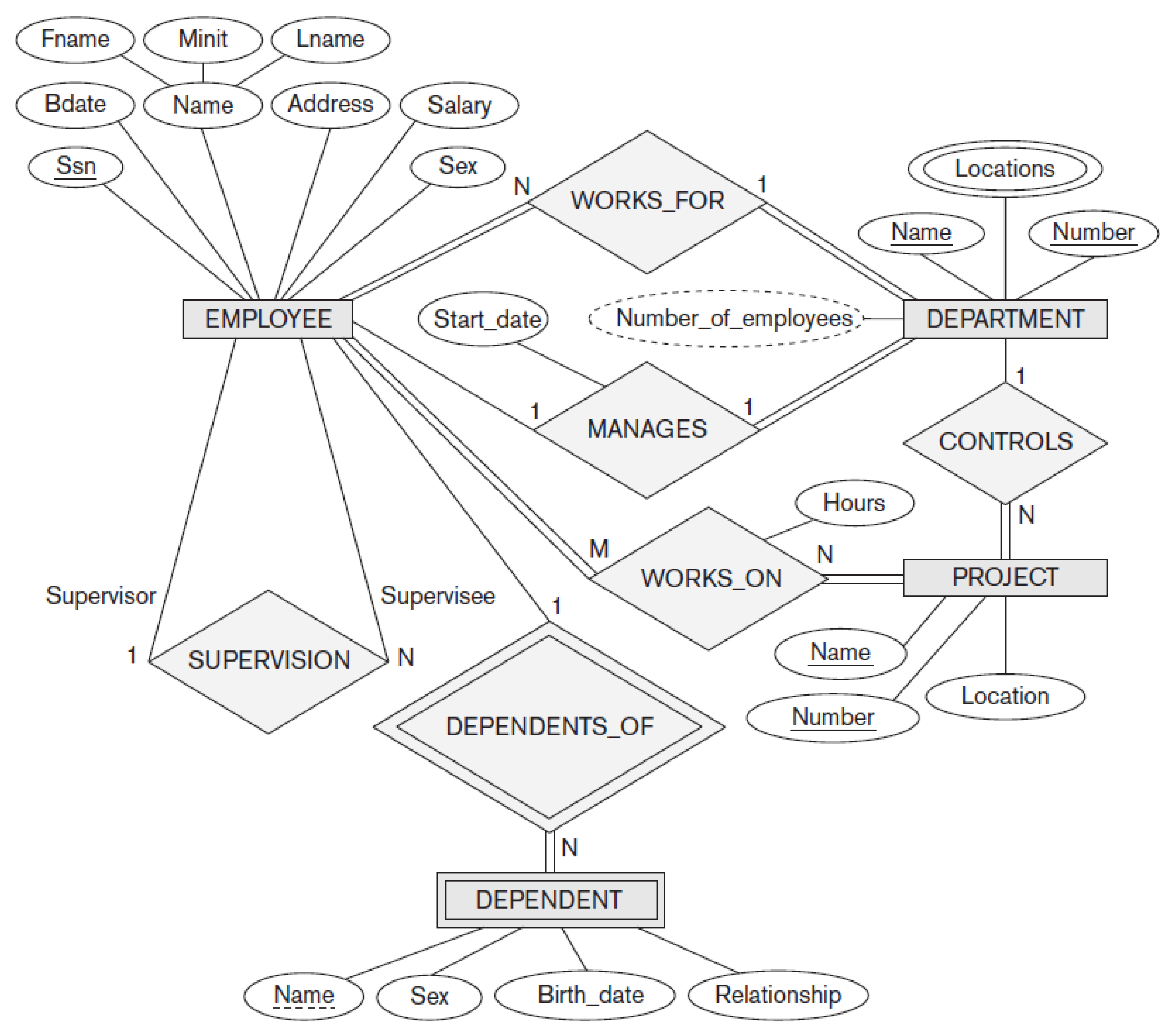

Figure 7.2
An ER schema diagram for the COMPANY database. The diagrammatic notation is introduced gradually throughout this chapter and is summarized in Figure 7.14.

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Entity Types, Entity Sets, Attributes, and Keys

- ER model describes data as:
  - Entities
  - Relationships
  - Attributes

Entities and Attributes

- **Entity**
  - Thing in real world with independent existence
- **Attributes**
  - Particular properties that describe entity
  - Types of attributes:
    - *Composite* versus *simple* (atomic) *attributes*
    - **Single-valued** versus **multivalued** attributes
    - **Stored** versus **derived** attributes
    - **NULL** values
    - **Complex** attributes

Entities and Attributes (cont'd.)

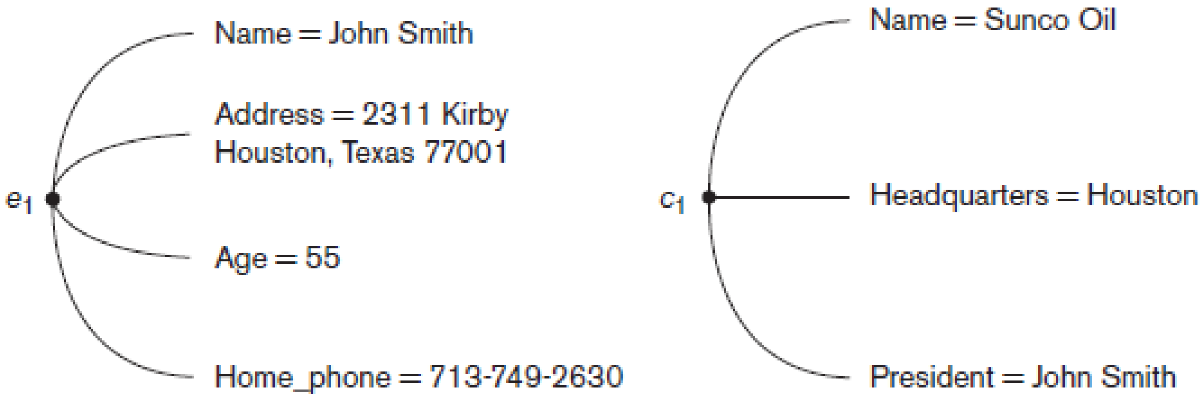

Figure 7.3
Two entities, EMPLOYEE e_1, and COMPANY c_1, and their attributes.

Entity Types, Entity Sets, Keys, and Value Sets

- **Entity type**
  - Collection (or set) of entities that have the same attributes

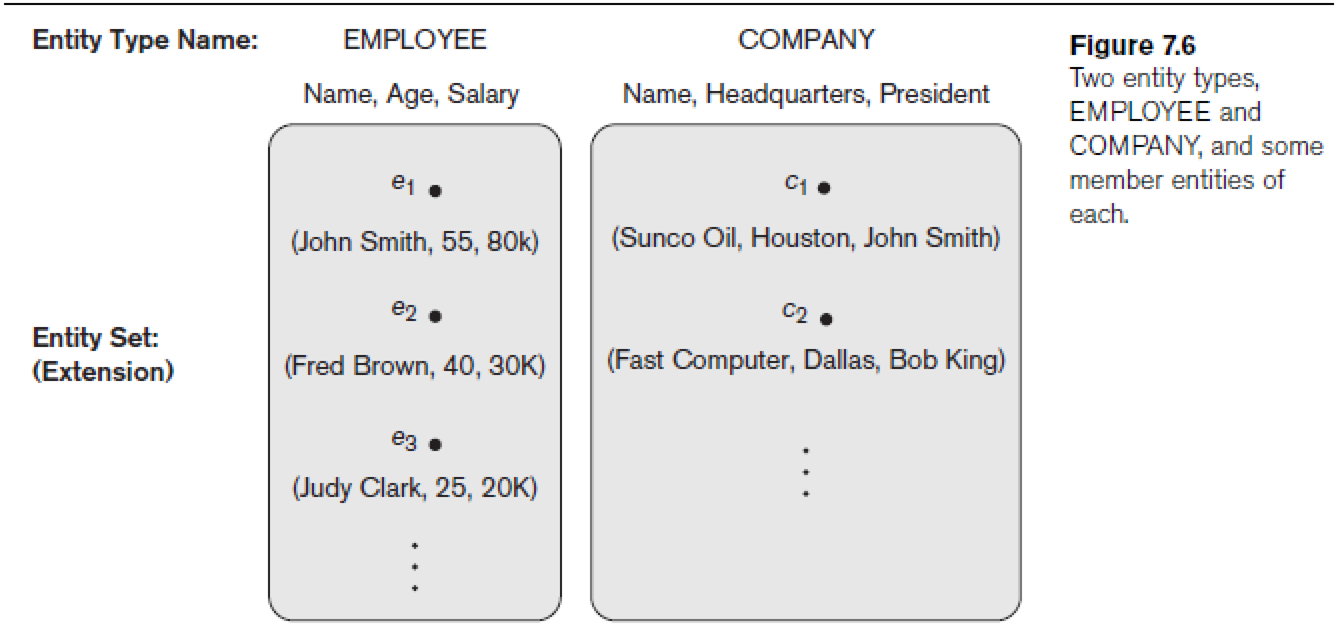

Figure 7.6
Two entity types, EMPLOYEE and COMPANY, and some member entities of each.

Entity Types, Entity Sets, Keys, and Value Sets (cont'd.)

- **Key** or **uniqueness constraint**
  - Attributes whose values are distinct for each individual entity in entity set
  - **Key attribute**
    - Uniqueness property must hold for every entity set of the entity type
- **Value sets** (or **domain of values**)
  - Specifies set of values that may be assigned to that attribute for each individual entity

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Initial Conceptual Design of the COMPANY Database

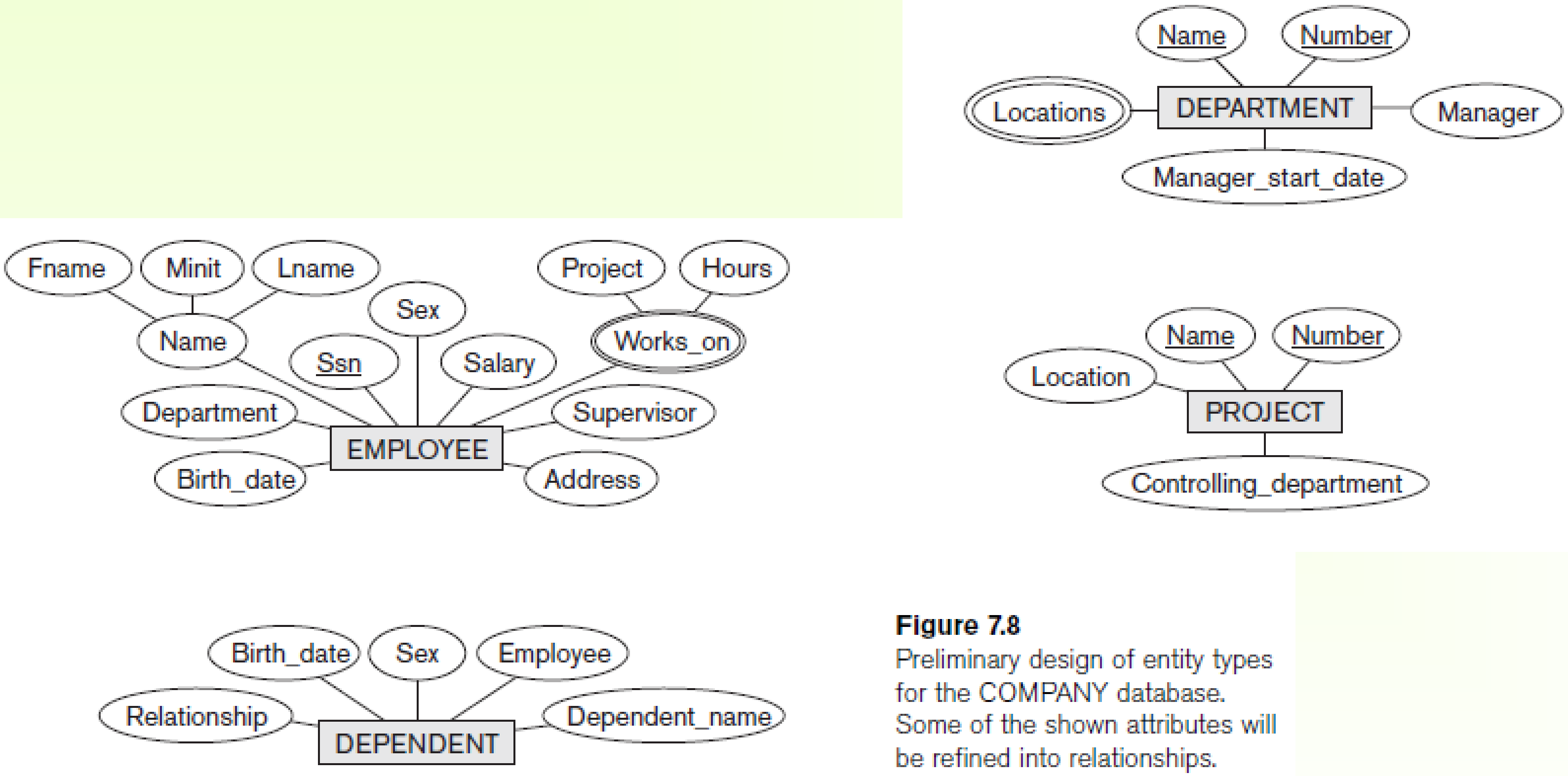

Figure 7.8
Preliminary design of entity types for the COMPANY database. Some of the shown attributes will be refined into relationships.

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Relationship Types, Relationship Sets, Roles, and Structural Constraints

- **Relationship**
  - When an attribute of one entity type refers to another entity type
  - Represent references as relationships not attributes

Relationship Types, Sets, and Instances

- **Relationship type** *R* among *n* entity types $E_1, E_2, \ldots, E_n$
  - Defines a set of associations among entities from these entity types
- **Relationship instances** r_i
  - Each r_i associates n individual entities (e_1, e_2, ..., e_n)
  - Each entity e_j in r_i is a member of entity set E_j

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Relationship Degree

- **Degree** of a relationship type
  - Number of participating entity types
  - **Binary**, **ternary**
- Relationships as attributes
  - Think of a binary relationship type in terms of attributes

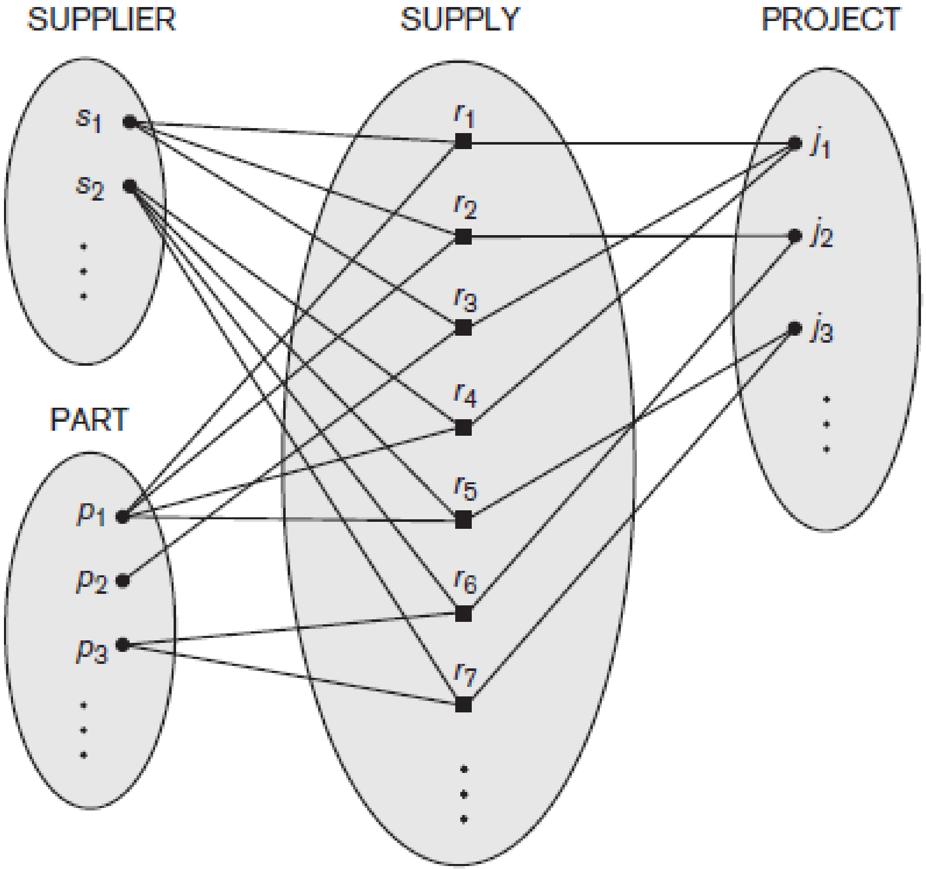

Figure 7.10
Some relationship instances in the SUPPLY ternary relationship set.

Role Names and Recursive Relationships

- **Role names** and recursive relationships
  - Role name signifies role that a participating entity plays in each relationship instance
- **Recursive** relationships
  - Same entity type participates more than once in a relationship type in different roles
  - Must specify role name

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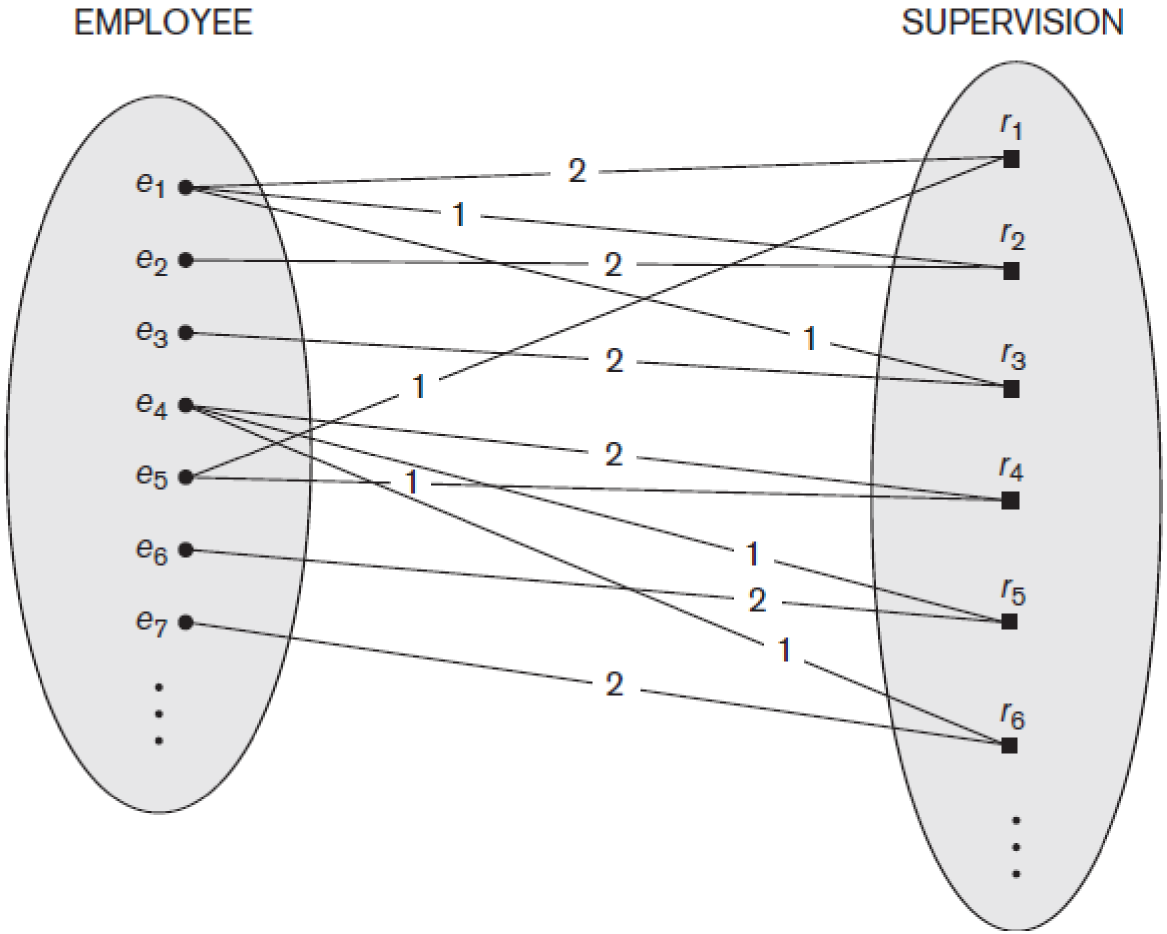

Figure 7.11
A recursive relationship SUPERVISION between EMPLOYEE in the *supervisor* role (1) and EMPLOYEE in the *subordinate* role (2).

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Constraints on Binary Relationship Types

- **Cardinality ratio** for a binary relationship
  - Specifies maximum number of relationship instances that entity can participate in
- **Participation constraint**
  - Specifies whether existence of entity depends on its being related to another entity
  - Types: **total** and **partial**

Attributes of Relationship Types

- Attributes of 1:1 relationship types can be migrated to one entity type
- For a 1:N relationship type
  - Relationship attribute can be migrated only to entity type on N-side of relationship
- For M:N relationship types
  - Some attributes may be determined by combination of participating entities
  - Must be specified as relationship attributes

Weak Entity Types

- Do not have key attributes of their own
  - Identified by being related to specific entities from another entity type
- **Identifying relationship**
  - Relates a weak entity type to its owner
- Always has a total participation constraint

Refining the ER Design for the COMPANY Database

- Change attributes that represent relationships into relationship types
- Determine cardinality ratio and participation constraint of each relationship type

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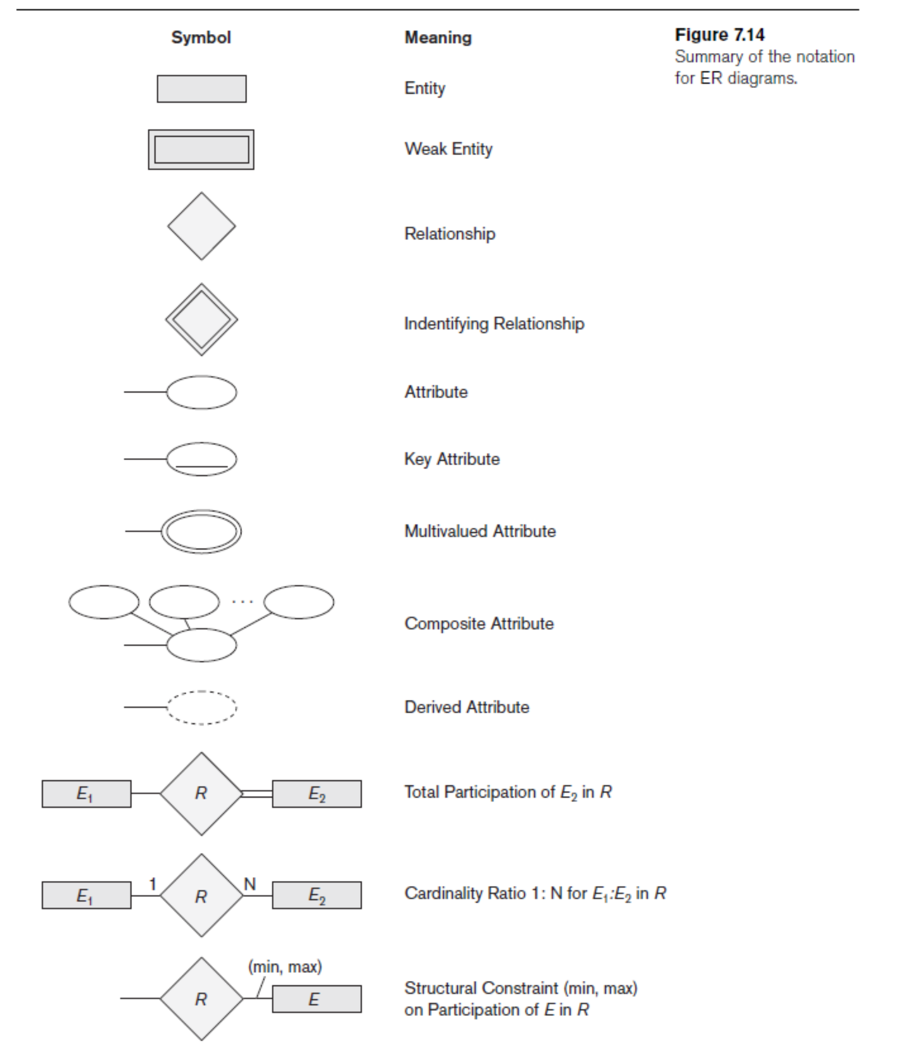
ER Diagrams, Naming Conventions, and Design Issues



Symbol	Meaning
	Entity
	Weak Entity
	Relationship
	Indentifying Relationship
	Attribute
	Key Attribute
	Multivalued Attribute
	Composite Attribute
	Derived Attribute
	Total Participation of E_2 in R
	Cardinality Ratio 1: N for E_1:E_2 in R
	Structural Constraint (min, max) on Participation of E in R

Figure 7.14
Summary of the notation for ER diagrams.

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Proper Naming of Schema Constructs

- Choose names that convey meanings attached to different constructs in schema
- Nouns give rise to entity type names
- Verbs indicate names of relationship types
- Choose binary relationship names to make ER diagram readable from left to right and from top to bottom

Design Choices for ER Conceptual Design

- Model concept first as an attribute
  - Refined into a relationship if attribute is a reference to another entity type
- Attribute that exists in several entity types may be elevated to an independent entity type
  - Can also be applied in the inverse

Alternative Notations for ER Diagrams

- Specify structural constraints on relationships
  - Replaces cardinality ratio (1:1, 1:N, M:N) and single/double line notation for participation constraints
  - Associate a pair of integer numbers (min, max) with each participation of an entity type *E* in a relationship type *R*, where 0 ≤ min ≤ max and max ≥ 1

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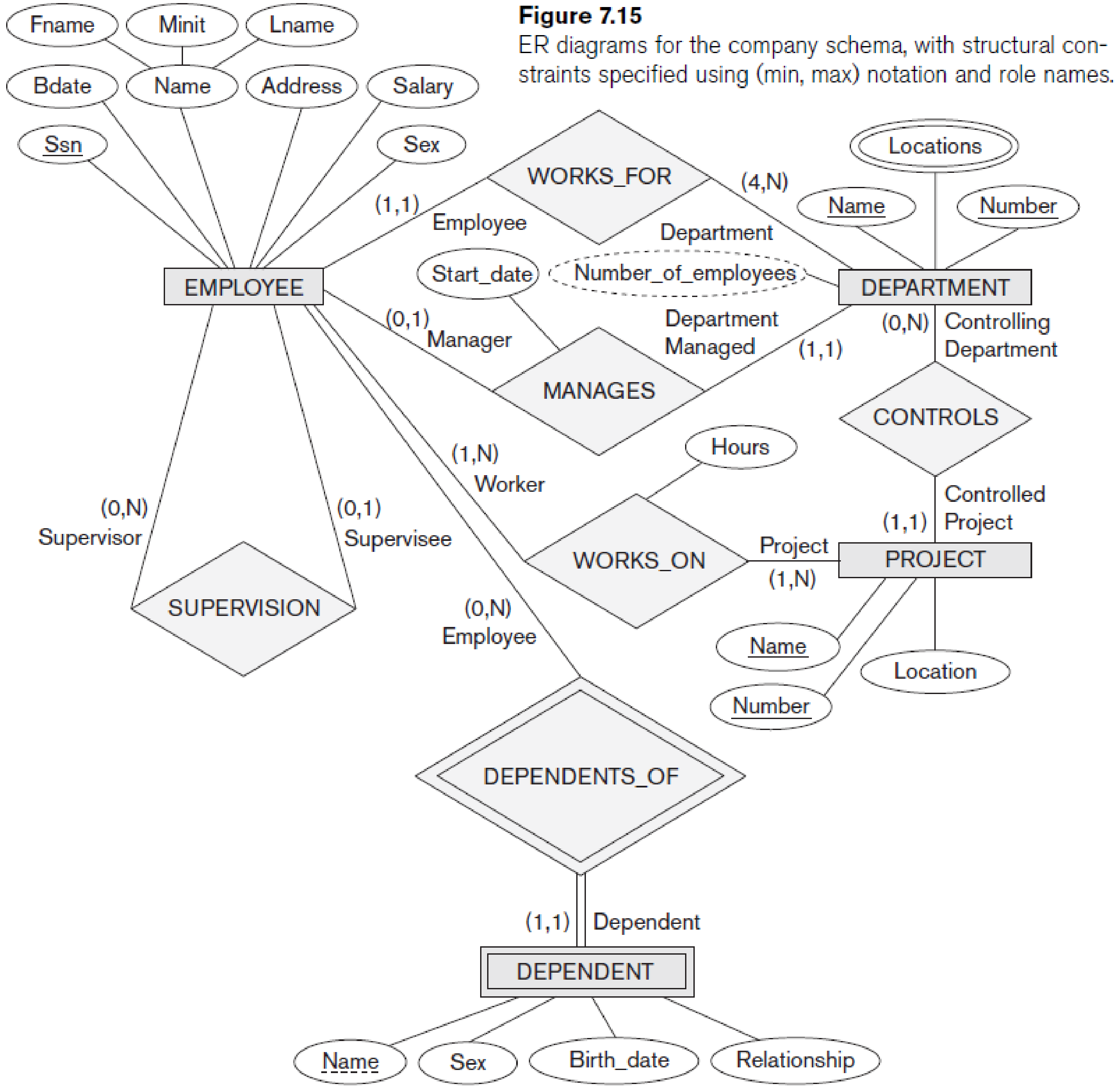

Figure 7.15
ER diagrams for the company schema, with structural constraints specified using (min, max) notation and role names.

Example of Other Notation: UML Class Diagrams

- UML methodology
  - Used extensively in software design
  - Many types of diagrams for various software design purposes
- UML class diagrams
  - Entity in ER corresponds to an object in UML

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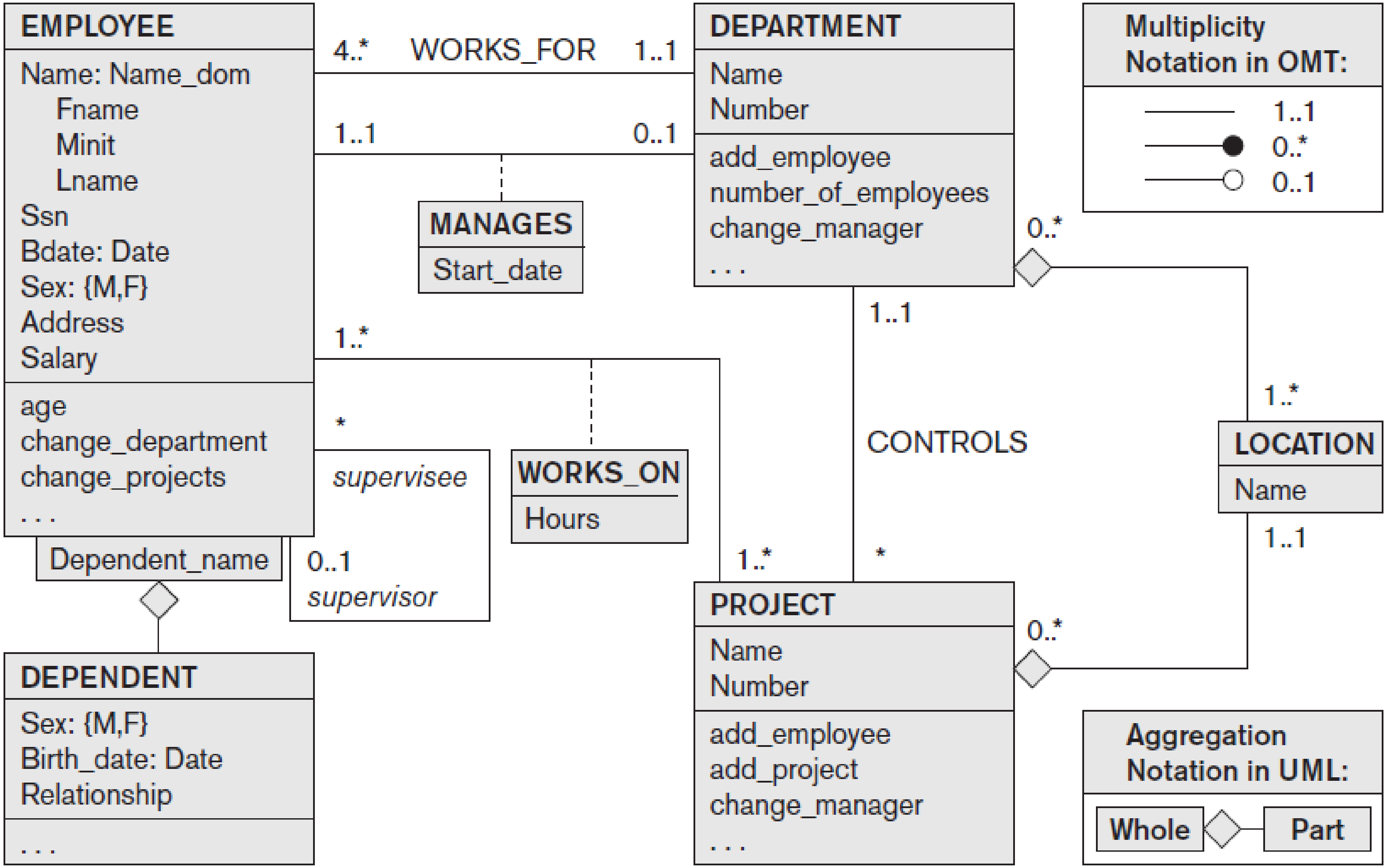
Figure 7.16
The COMPANY conceptual schema
in UML class diagram notation.



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Example of Other Notation: UML Class Diagrams (cont'd.)

- **Class** includes three sections:
  - Top section gives the class name
  - Middle section includes the attributes;
  - Last section includes operations that can be applied to individual objects

Relationship Types of Degree Higher than Two

- **Degree** of a relationship type
  - Number of participating entity types
- *Binary*
  - Relationship type of degree two
- *Ternary*
  - Relationship type of degree three

Choosing between Binary and Ternary (or Higher-Degree) Relationships

- Some database design tools permit only binary relationships
  - Ternary relationship must be represented as a weak entity type
  - No partial key and three identifying relationships
- Represent ternary relationship as a regular entity type
  - By introducing an artificial or surrogate key

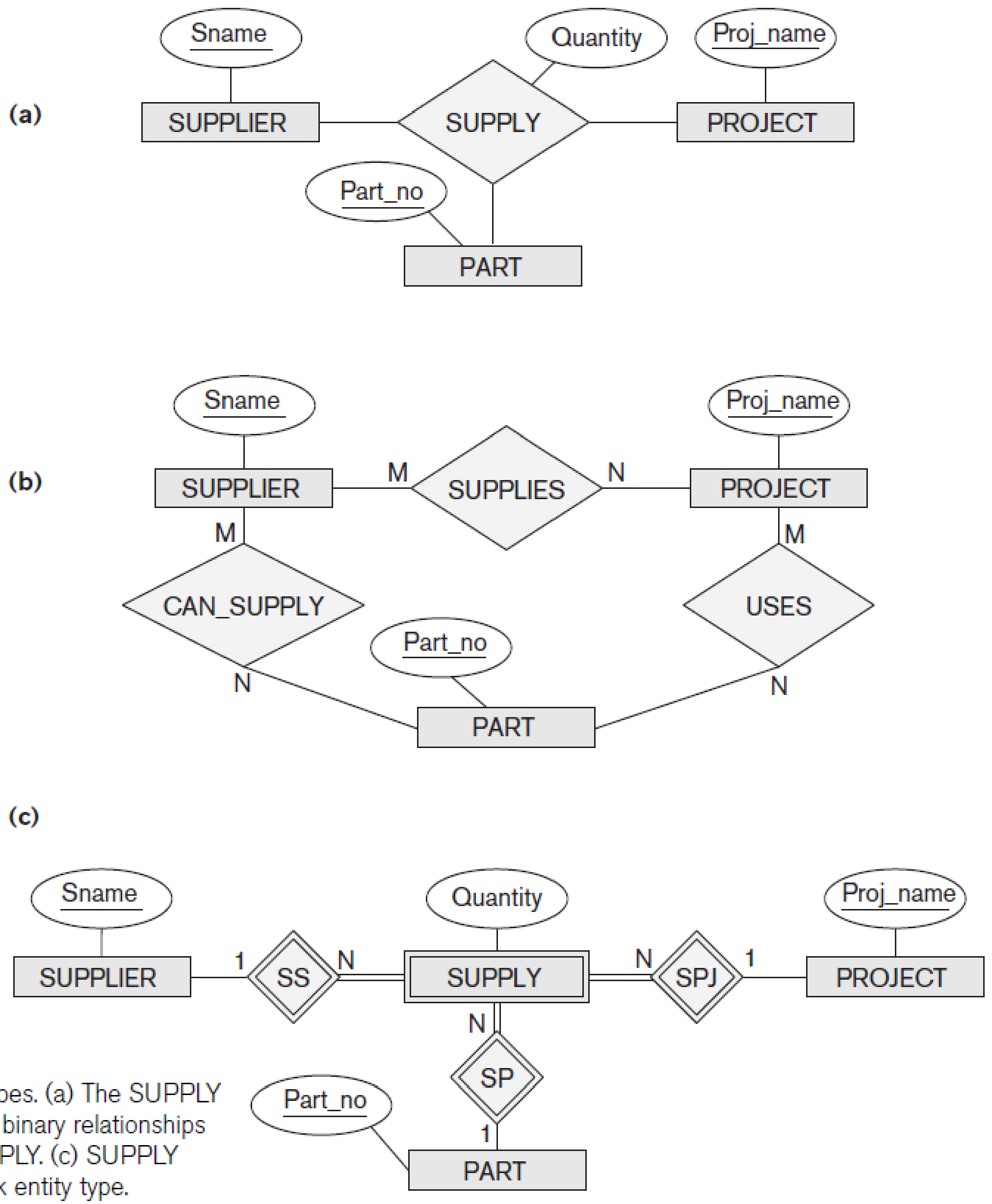

Figure 7.17
Ternary relationship types. (a) The SUPPLY relationship. (b) Three binary relationships not equivalent to SUPPLY. (c) SUPPLY represented as a weak entity type.

Constraints on Ternary (or Higher-Degree) Relationships

- Notations for specifying structural constraints on *n*-ary relationships
  - Should both be used if it is important to fully specify structural constraints

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Summary

- Basic ER model concepts of entities and their attributes
  - Different types of attributes
  - Structural constraints on relationships
- ER diagrams represent E-R schemas
- UML class diagrams relate to ER modeling concepts