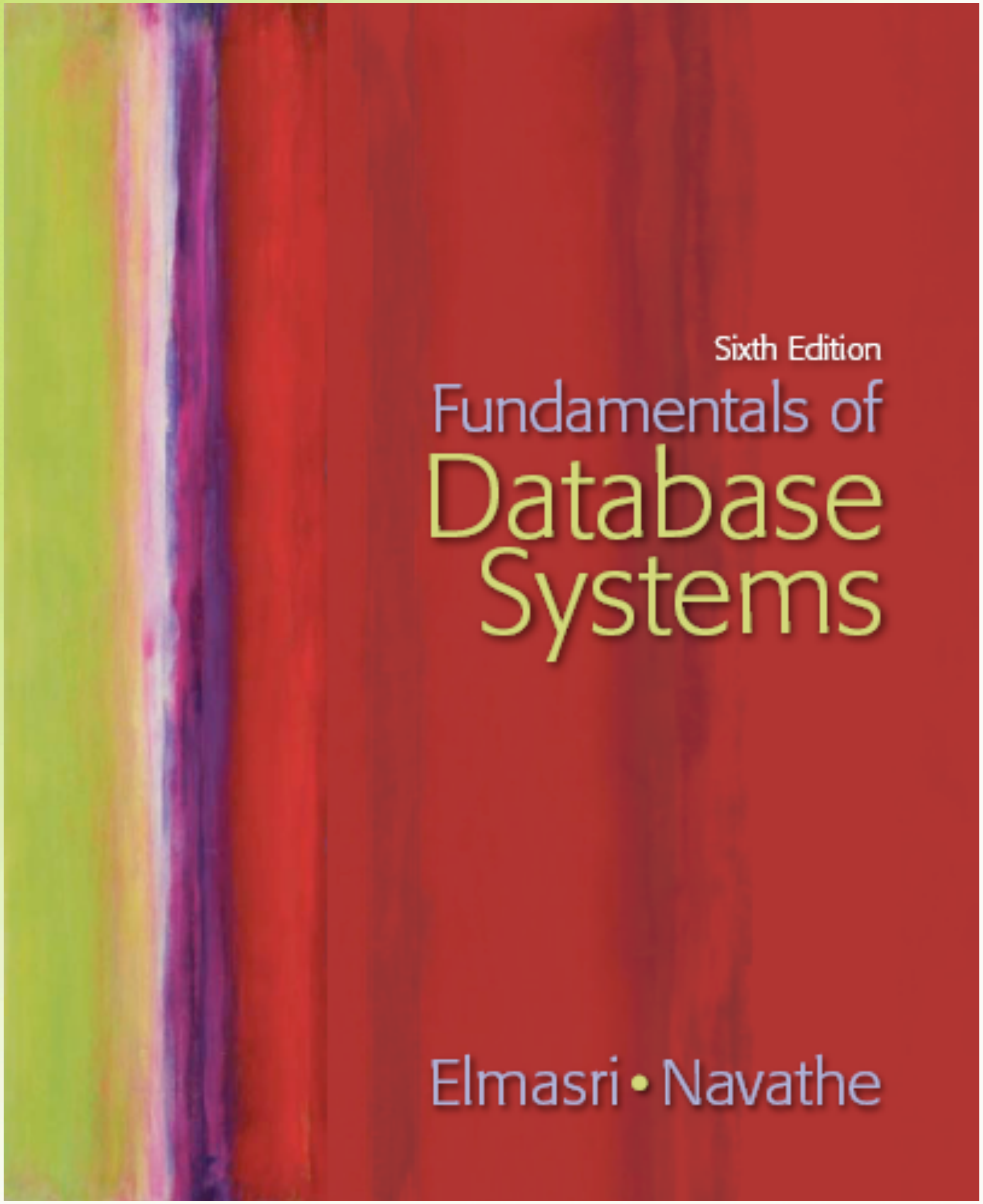
Chapter 8

The Enhanced Entity-Relationship (EER) Model



Sixth Edition

Fundamentals of Database Systems

Elmasri • Navathe

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Chapter 8 Outline

- Subclasses, Superclasses, and Inheritance
- Specialization and Generalization
- Constraints and Characteristics of Specialization and Generalization Hierarchies
- Modeling of UNION Types Using Categories

Chapter 8 Outline (cont'd.)

- A Sample UNIVERSITY EER Schema, Design Choices, and Formal Definitions
- Example of Other Notation: Representing Specialization and Generalization in UML Class Diagrams
- Data Abstraction, Knowledge Representation, and Ontology Concepts

The Enhanced Entity-Relationship (EER) Model

- **Enhanced ER (EER) model**
  - Created to design more accurate database schemas
    - Reflect the data properties and constraints more precisely
  - More complex requirements than traditional applications

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Subclasses, Superclasses, and Inheritance

- EER model includes all modeling concepts of the ER model
- In addition, EER includes:
  - **Subclasses** and **superclasses**
  - **Specialization** and **generalization**
  - **Category** or **union type**
  - **Attribute** and **relationship inheritance**

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Subclasses, Superclasses, and Inheritance (cont'd.)

- **Enhanced ER** or **EER diagrams**
  - Diagrammatic technique for displaying these concepts in an EER schema
- **Subtype** or **subclass** of an entity type
  - Subgroupings of entities that are meaningful
  - Represented explicitly because of their significance to the database application

Subclasses, Superclasses, and Inheritance (cont'd.)

- Terms for relationship between a superclass and any one of its subclasses
  - **Superclass/subclass**
  - **Supertype/subtype**
  - **Class/subclass** relationship
- **Type inheritance**
  - Subclass entity inherits all attributes and relationships of superclass

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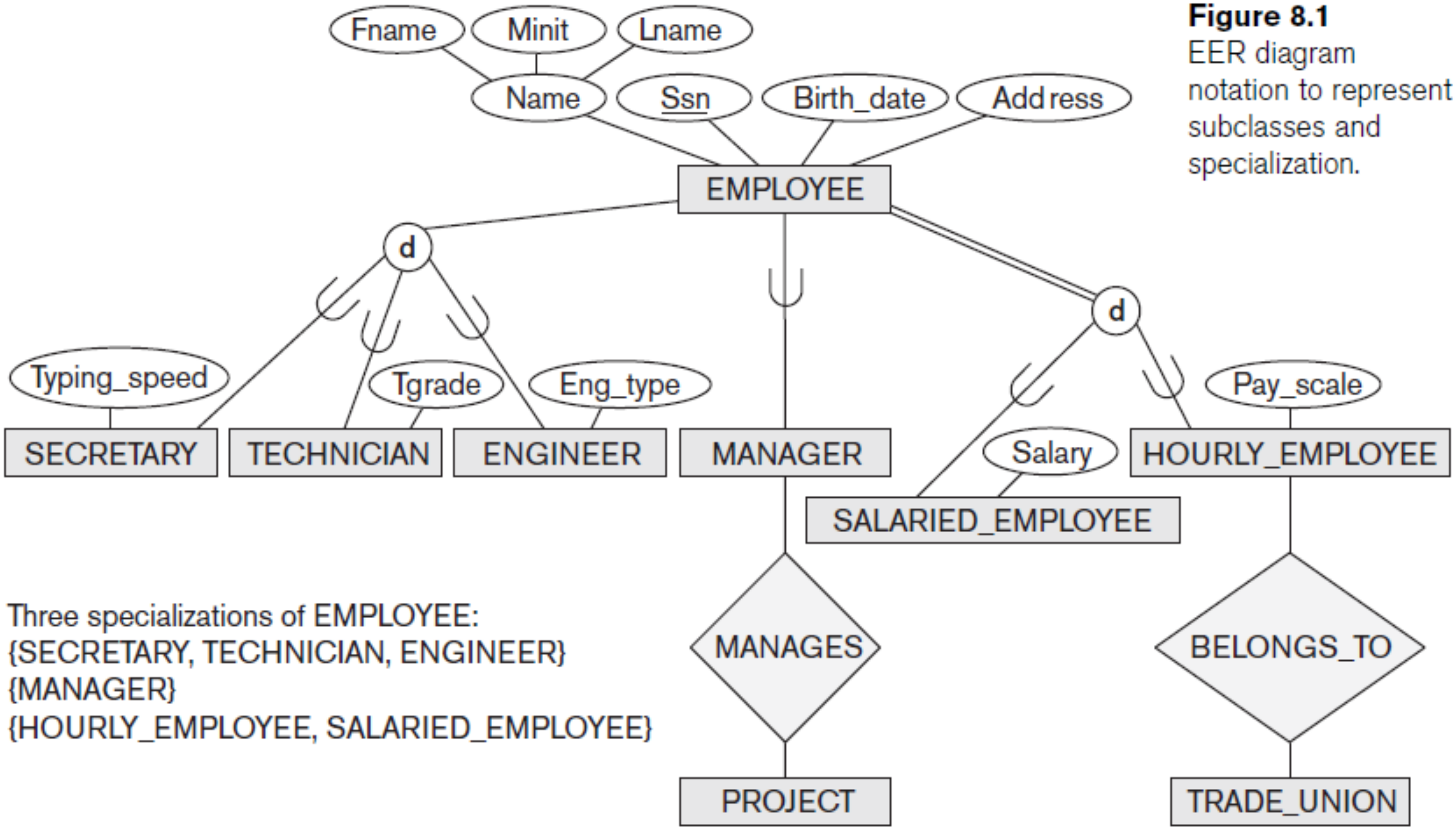

Figure 8.1
EER diagram notation to represent subclasses and specialization.

Three specializations of EMPLOYEE:
{SECRETARY, TECHNICIAN, ENGINEER}
{MANAGER}
{HOURLY_EMPLOYEE, SALARIED_EMPLOYEE}

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Specialization and Generalization

- **Specialization**
  - Process of defining a set of subclasses of an entity type
  - Defined on the basis of some distinguishing characteristic of the entities in the superclass
- Subclass can define:
  - **Specific attributes**
  - **Specific relationship types**

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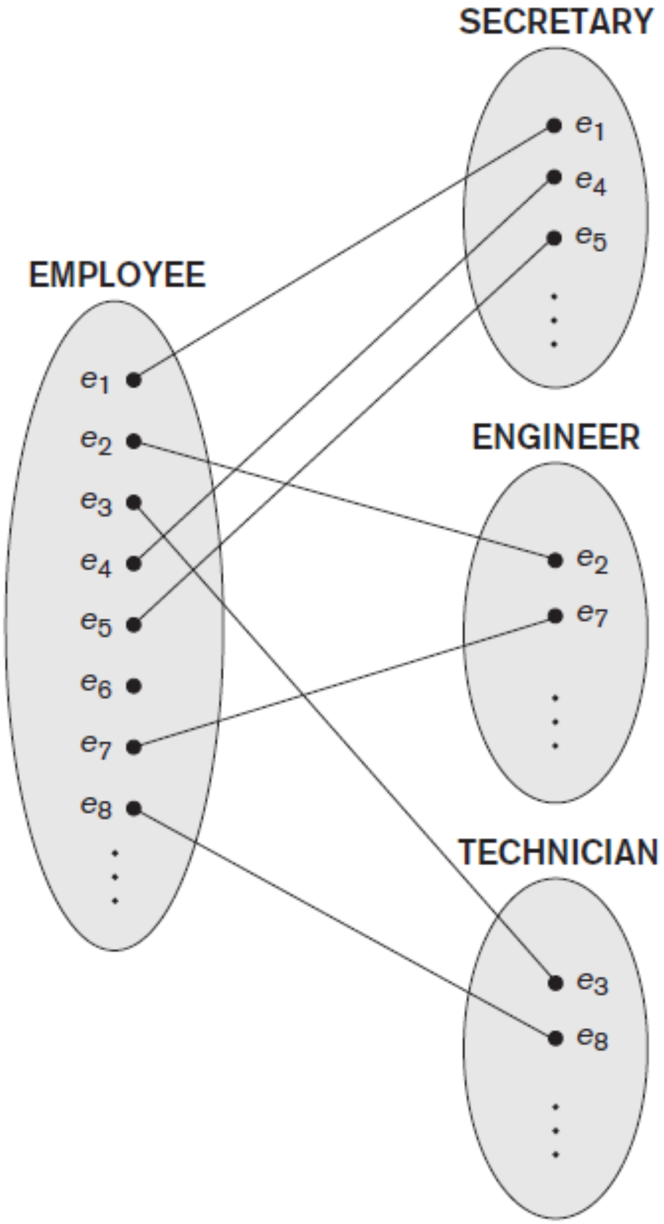

Figure 8.2
Instances of a specialization.

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Specialization and Generalization (cont'd.)

- Certain attributes may apply to some but not all entities of the superclass
- Some relationship types may be participated in only by members of the subclass

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Generalization

- Reverse process of abstraction
- **Generalize** into a single **superclass**
    - Original entity types are special subclasses
- **Generalization**
    - Process of defining a generalized entity type from the given entity types

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Constraints and Characteristics of Specialization and Generalization Hierarchies

- Constraints that apply to a single specialization or a single generalization
- Differences between specialization/ generalization lattices and hierarchies

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Constraints on Specialization and Generalization

- May be several or one subclass
- Determine entity subtype:
  - **Predicate-defined** (or **condition-defined**) **subclasses**
  - **Attribute-defined specialization**
  - **User-defined**

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Constraints on Specialization and Generalization (cont'd.)

- **Disjointness constraint**
  - Specifies that the subclasses of the specialization must be disjoint
- **Completeness** (or **totalness**) **constraint**
  - May be **total** or **partial**
- Disjointness and completeness constraints are independent

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Specialization and Generalization Hierarchies and Lattices

- **Specialization hierarchy**
  - Every subclass participates as a subclass in only one class/subclass relationship
  - Results in a **tree structure** or **strict hierarchy**
- **Specialization lattice**
  - Subclass can be a subclass in more than one class/subclass relationship

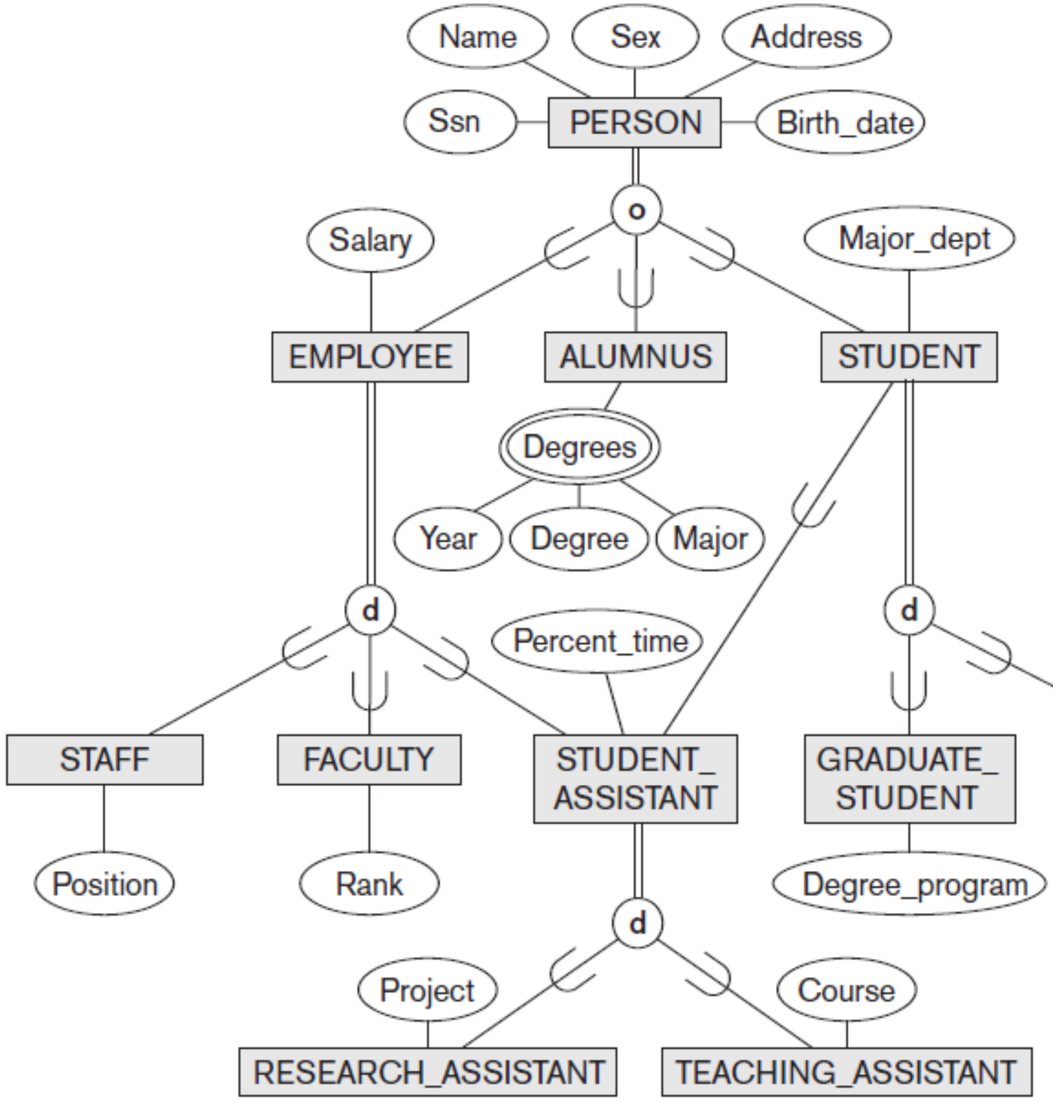

Figure 8.7
A specialization lattice with multiple inheritance for a UNIVERSITY database.

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Specialization and Generalization Hierarchies and Lattices (cont'd.)

- **Multiple inheritance**
  - Subclass with more than one superclass
  - If attribute (or relationship) originating in the same superclass inherited more than once via different paths in lattice
    - Included only once in shared subclass
- **Single inheritance**
  - Some models and languages limited to single inheritance

Utilizing Specialization and Generalization in Refining Conceptual Schemas

- Specialization process
  - Start with entity type then define subclasses by successive specialization
  - **Top-down conceptual refinement process**
- **Bottom-up conceptual synthesis**
  - Involves generalization rather than specialization

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Modeling of UNION Types Using Categories

- **Union type** or a **category**
  - Represents a single superclass/subclass relationship with more than one superclass
  - Subclass represents a collection of objects that is a subset of the UNION of distinct entity types
  - Attribute inheritance works more selectively
  - Category can be **total** or **partial**
- Some modeling methodologies do not have union types

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A Sample UNIVERSITY EER Schema, Design Choices, and Formal Definitions

- The UNIVERSITY Database Example
  - UNIVERSITY database
    - Students and their majors
    - Transcripts, and registration
    - University’s course offerings

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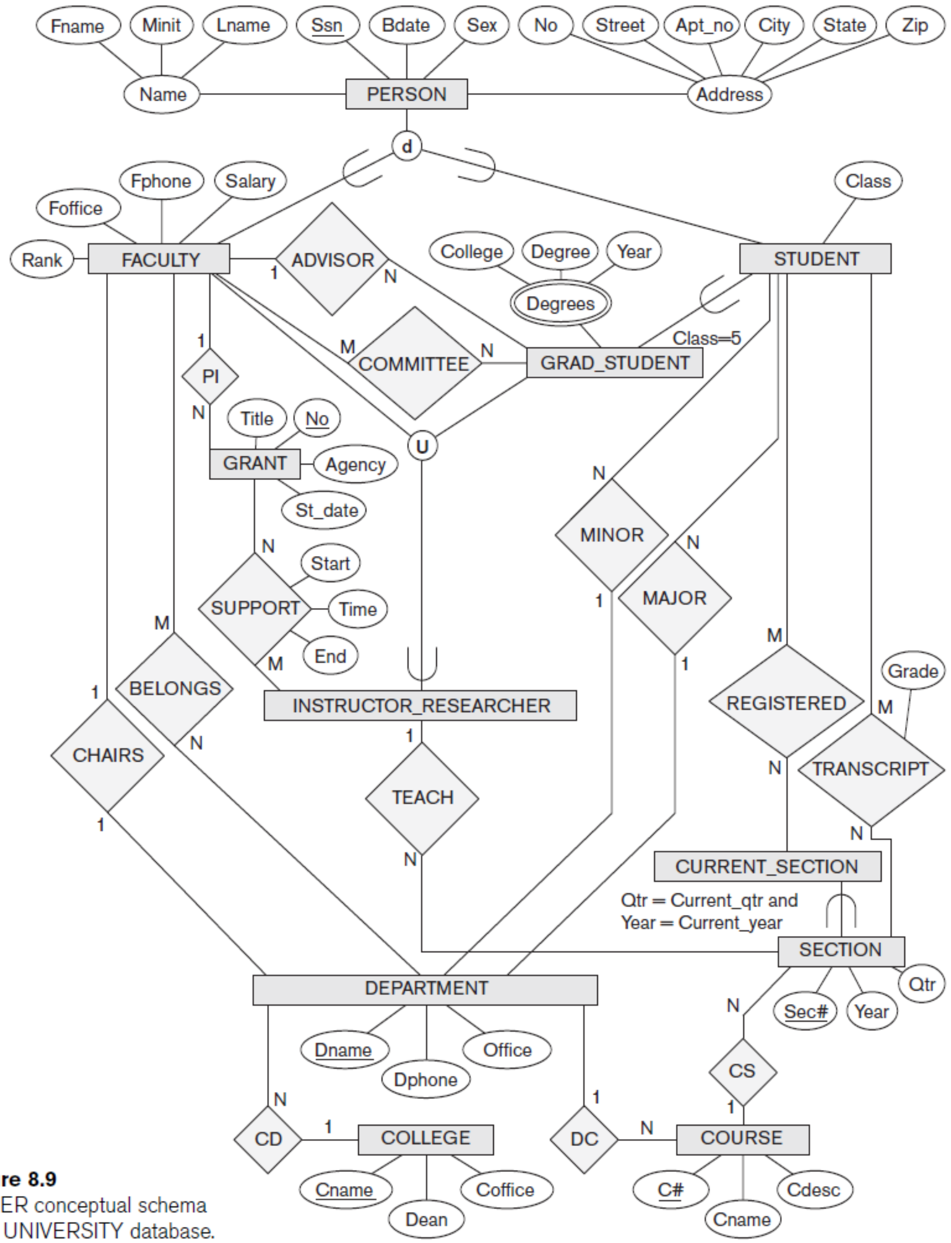

Figure 8.9
An EER conceptual schema
for a UNIVERSITY database.

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Design Choices for Specialization/Generalization

- Many specializations and subclasses can be defined to make the conceptual model accurate
- If subclass has few specific attributes and no specific relationships
  - Can be merged into the superclass

Design Choices for Specialization/Generalization (cont'd.)

- If all the subclasses of a specialization/ generalization have few specific attributes and no specific relationships
  - Can be merged into the superclass
  - Replace with one or more type attributes that specify the subclass or subclasses that each entity belongs to

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Design Choices for Specialization/Generalization (cont'd.)

- Union types and categories should generally be avoided
- Choice of disjoint/overlapping and total/partial constraints on specialization/generalization
  - Driven by rules in miniworld being modeled

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Formal Definitions for the EER Model Concepts

- **Class**
  - Set or collection of entities
  - Includes any of the EER schema constructs of group entities
- **Subclass**
  - Class whose entities must always be a subset of the entities in another class
- **Specialization**
  - Set of subclasses that have same superclass

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Formal Definitions for the EER Model Concepts (cont'd.)

- **Generalization**
    - Generalized entity type or superclass
- **Predicate-defined**
    - Predicate on the attributes of is used to specify which entities in *C* are members of *S*
- **User-defined**
    - Subclass that is not defined by a predicate

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Formal Definitions for the EER Model Concepts (cont'd.)

- **Category**
  - Class that is a subset of the union of n defining superclasses
- **Relationship type**
  - Any class can participate in a relationship

Example of Other Notation

- Representing specialization and generalization in UML class diagrams
  - Basic notation
    - See Figure 8.10
  - Base class
    - Root superclass
  - Leaf classes
    - Subclasses (leaf nodes)

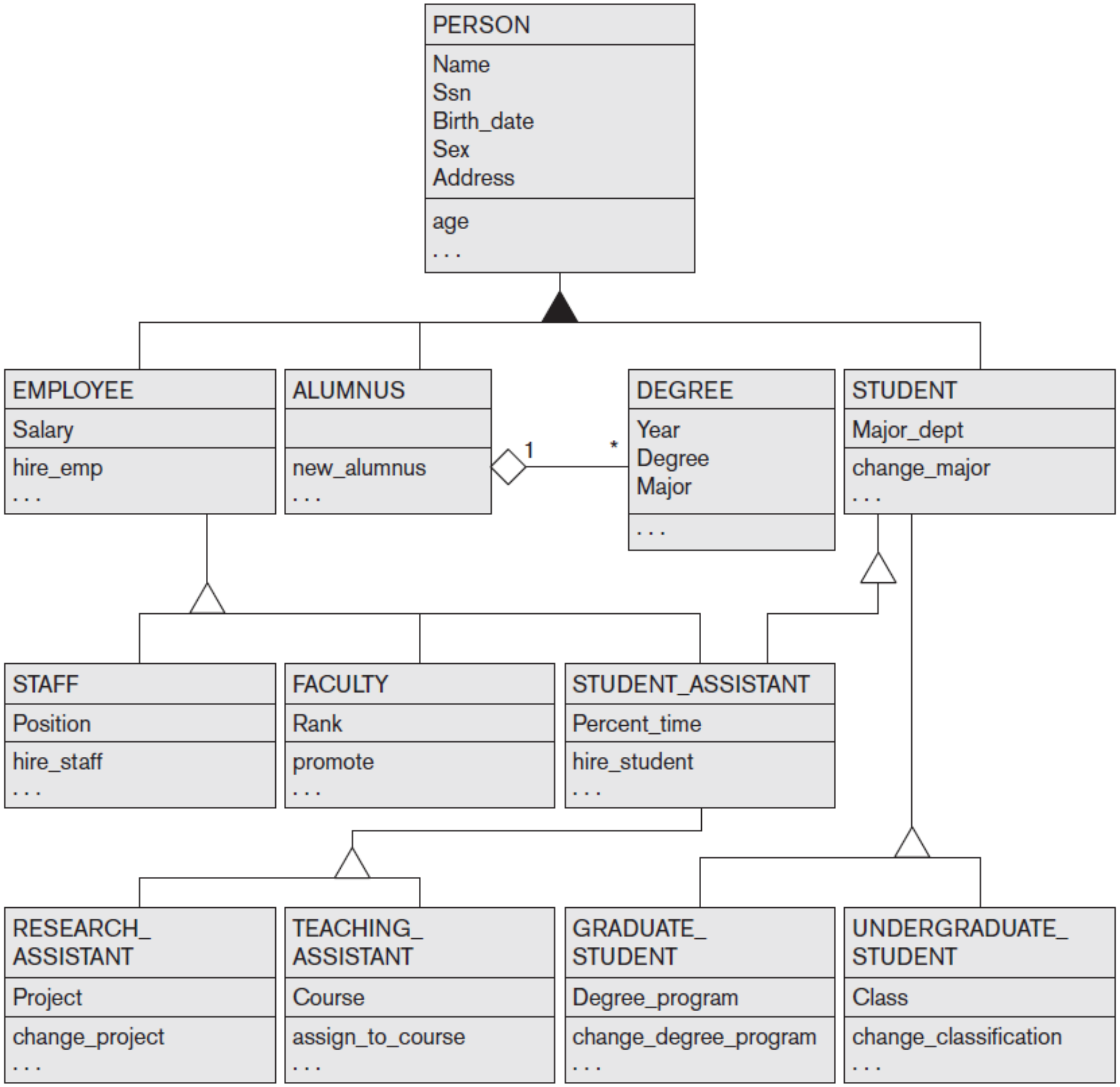

Figure 8.10
A UML class diagram corresponding to the EER diagram in Figure 8.7, illustrating UML notation for specialization/generalization.

Data Abstraction, Knowledge Representation, and Ontology Concepts

- Goal of **knowledge representation (KR)** techniques
  - Accurately model some **domain of knowledge**
  - Create an **ontology** that describes the concepts of the domain and how these concepts are interrelated
- Goals of KR are similar to those of semantic data models
  - Important similarities and differences

Classification and Instantiation

- **Classification**
  - Systematically assigning similar objects/entities to object classes/entity types
- **Instantiation**
  - Inverse of classification
  - Generation and specific examination of distinct objects of a class

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Classification and Instantiation (cont'd.)

- **Exception objects**
  - Differ in some respects from other objects of class
  - KR schemes allow such **class properties**
- One class can be an instance of another class (called a meta-class)
  - Cannot be represented directly in EER model

Identification

- Abstraction process
- Classes and objects are made uniquely identifiable by means of some **identifier**
- Needed at two levels
  - To distinguish among database objects and classes
  - To identify database objects and to relate them to their real-world counterparts

Specialization and Generalization

- **Specialization**
  - Classify a class of objects into more specialized subclasses
- **Generalization**
  - Generalize several classes into a higher-level abstract class
  - Includes the objects in all these classes

Aggregation and Association

- **Aggregation**
  - Abstraction concept for building composite objects from their component objects
- **Association**
  - Associate objects from several independent classes
- Main structural distinction
  - When an association instance is deleted
    - Participating objects may continue to exist

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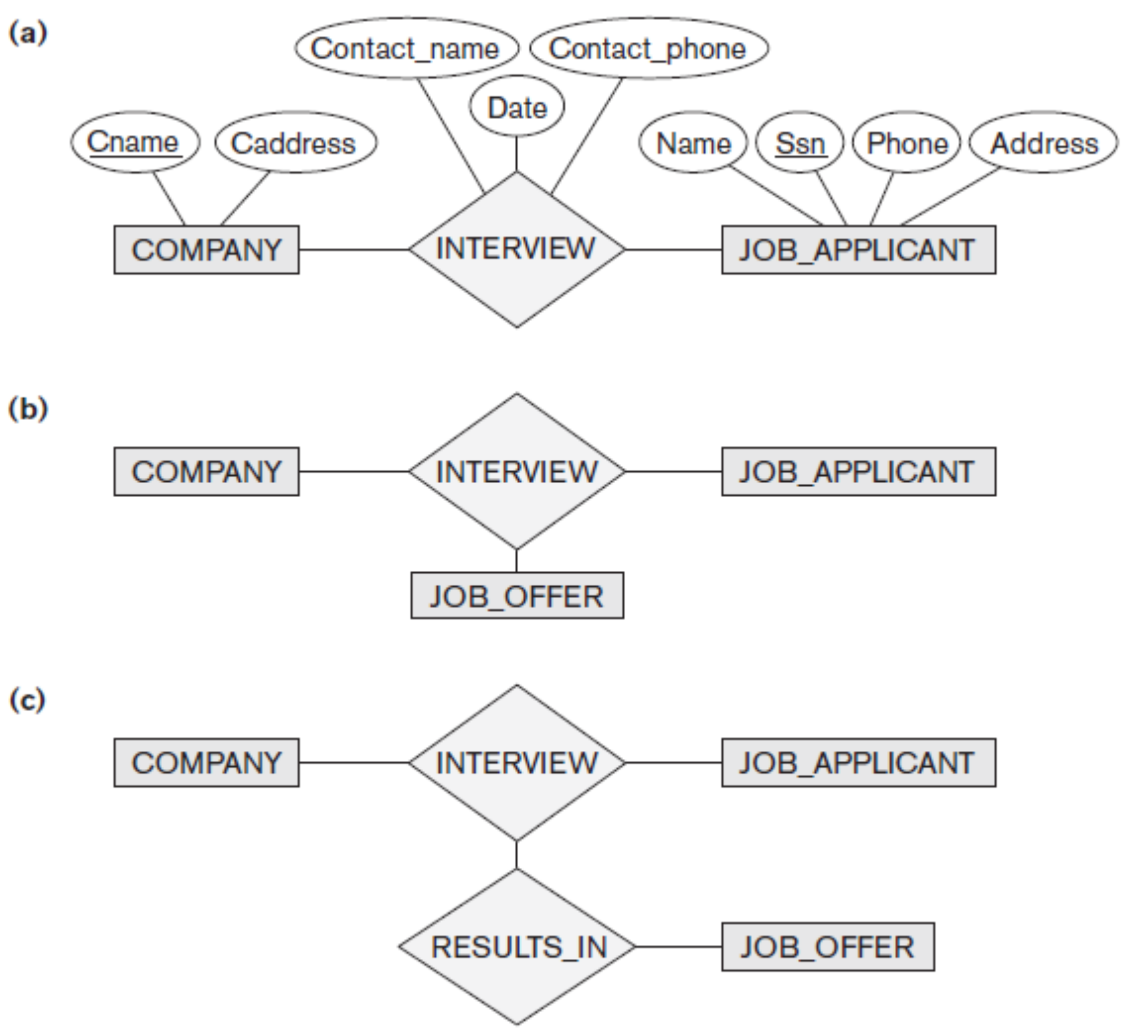

Figure 8.11
Aggregation. (a) The relationship type INTERVIEW. (b) Including JOB_OFFER in a ternary relationship type (incorrect). (c) Having the RESULTS_IN relationship participate in other relationships (not allowed in ER). (d) Using aggregation and a composite (molecular) object (generally not allowed in ER but allowed by some modeling tools). (e) Correct representation in ER.

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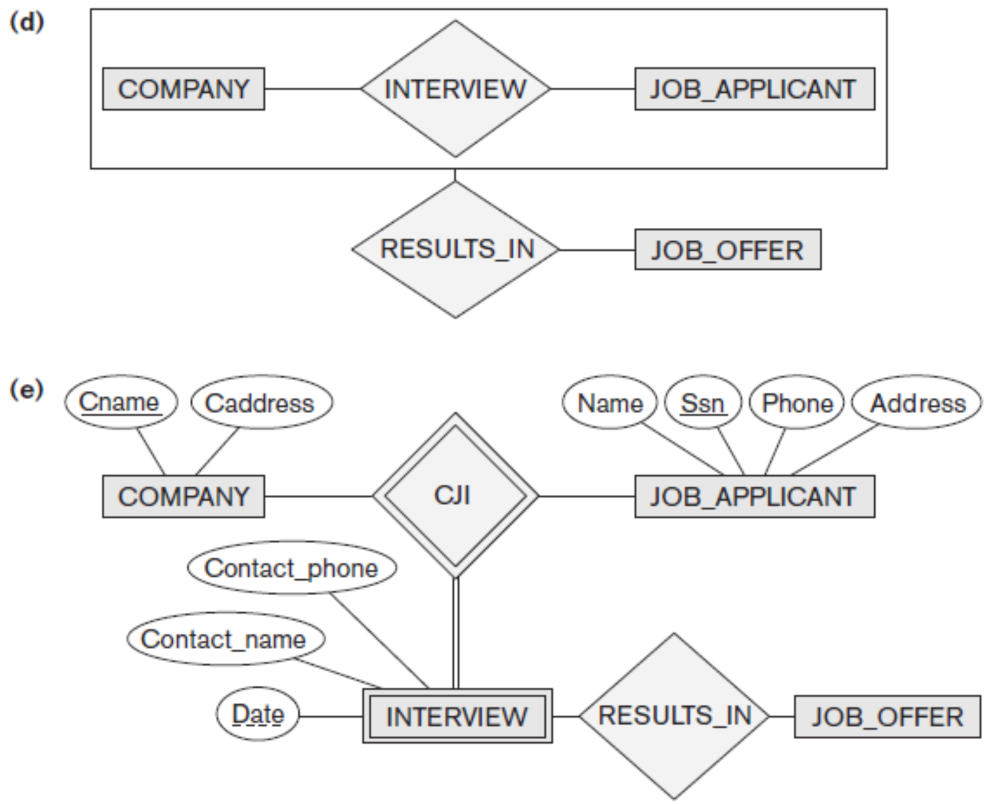

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Ontologies and the Semantic Web

- Documents contain less structure than database information does
- **Semantic Web**
  - Allow meaningful information exchange and search among machines
- **Ontology**
  - Specification of a **conceptualization**
- **Specification**
  - Language and vocabulary terms used to specify conceptualization

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Summary

- Enhanced ER or EER model
    - Extensions to ER model that improve its representational capabilities
    - Subclass and its superclass
    - Category or union type
- Notation and terminology of UML for representing specialization and generalization