Chapter 8: The Enhanced Entity-Relationship (EER) Model

CS-6360 Database Design

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Chapter 8 Outline

- 8.1 – Subclasses, Superclasses, and Inheritance

- 8.2 – Specialization and Generalization

- 8.3 – Constraints and Characteristics of Specialization and Generalization Hierarchies

- 8.4 – Modeling of UNION Types Using Categories

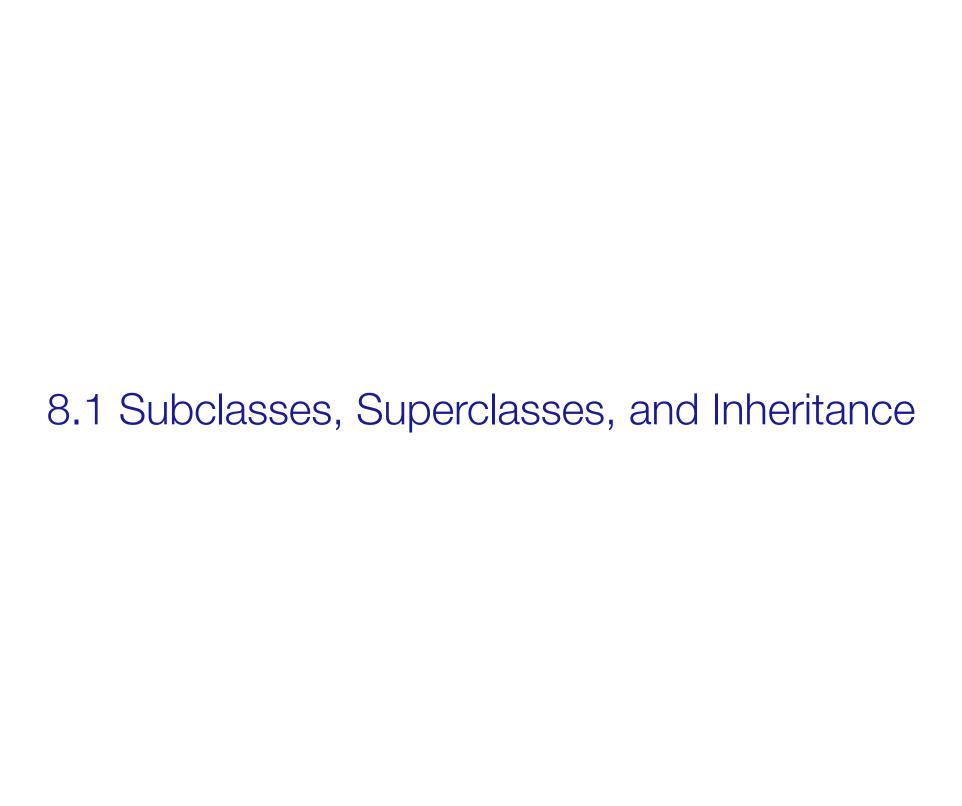# The Enhanced Entity-Relationship (EER) Model UTD

- **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

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**

8.1 Subclasses, Superclasses, and Inheritance

- **Enhanced ER** or **EER diagrams**

  - Diagrammatic technique for displaying these concepts in an EER schema

- **Subtype** or **subclass** of an entity type

  - Sub-groupings of entities that are meaningful

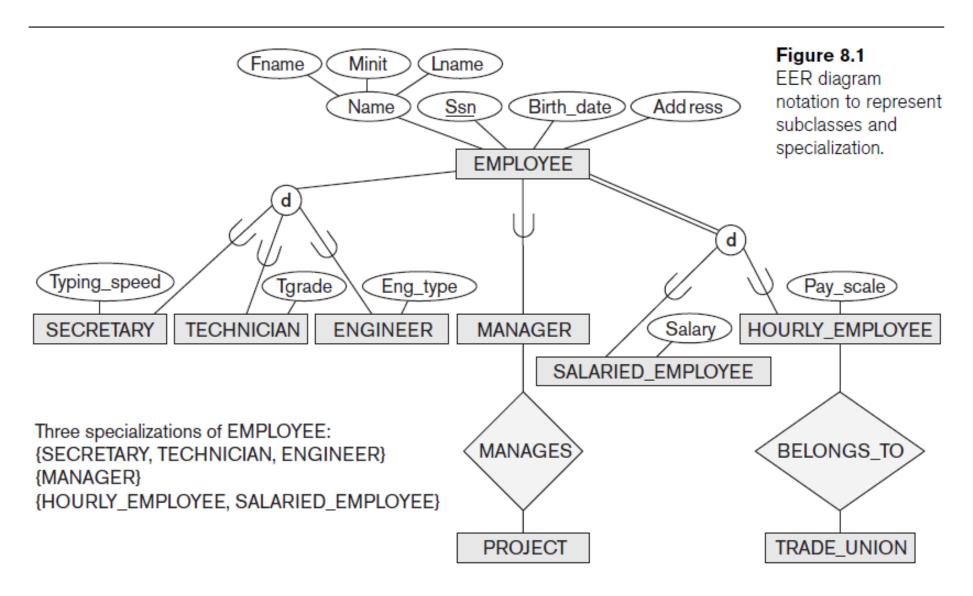 - Represented explicitly because of their significance to the database application

- 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

Subclass and Specialization

Figure 8.1
EER diagram notation to represent subclasses and specialization.

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

8.2 Specialization and Generalization

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:

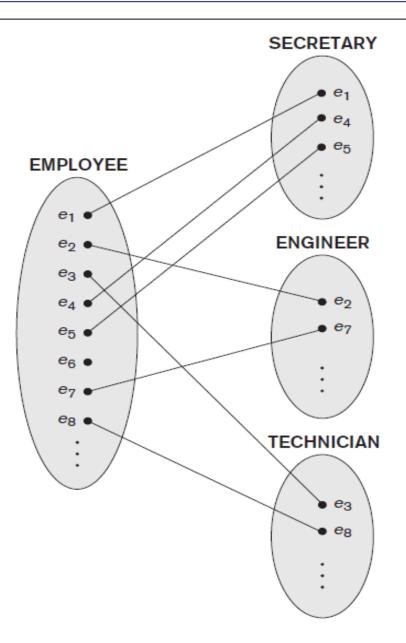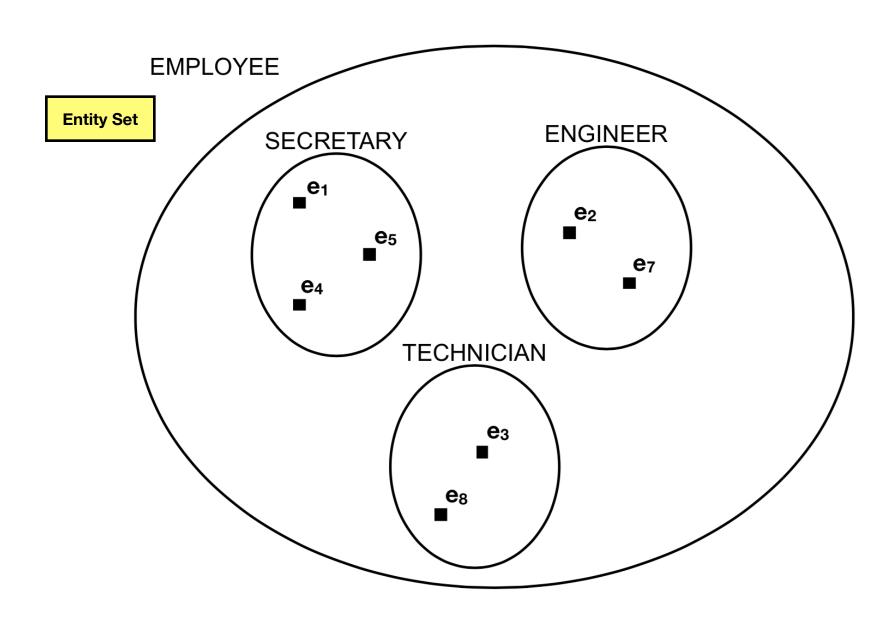 - **Specific attributes**
  - **Specific relationship types**

Figure 8.2
Instances of a specialization.

Entity Subsets

EMPLOYEE

Entity Set

SECRETARY

ENGINEER

e_1

e_5

e_4

e_2

e_7

TECHNICIAN

e_3

e_8

Specialization and Generalization (cont'd.)

- Two main reasons for including class/subclass relationships and specializations in a data model:

  - 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

Generalization

- Reverse process of specialization, which is 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
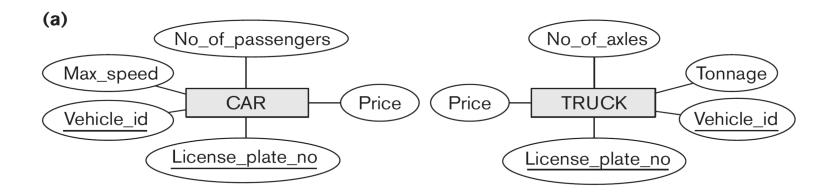
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Generalization Example

(a)

Figure 8.3
Generalization. (a) Two entity types, CAR and TRUCK. (b)
Generalizing CAR and TRUCK into the superclass VEHICLE.
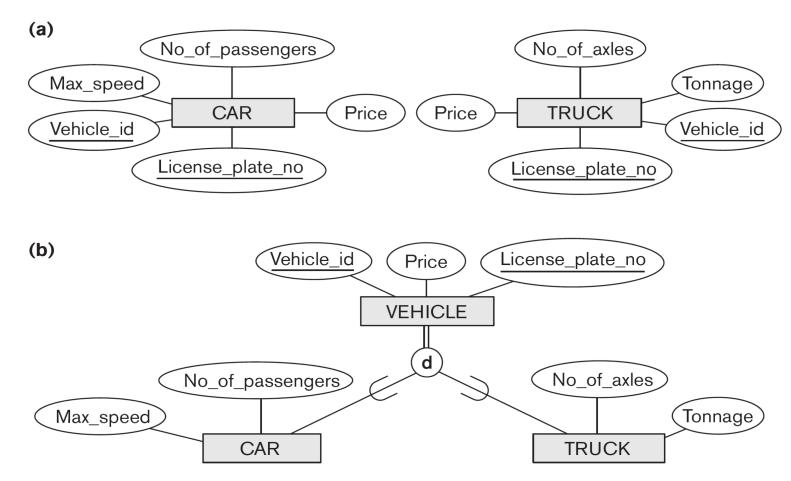
Generalization Example

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(b)

Figure 8.3
Generalization. (a) Two entity types, CAR and TRUCK. (b)
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8.3 Constraints and Characteristics of Specialization and Generalization Hierarchies

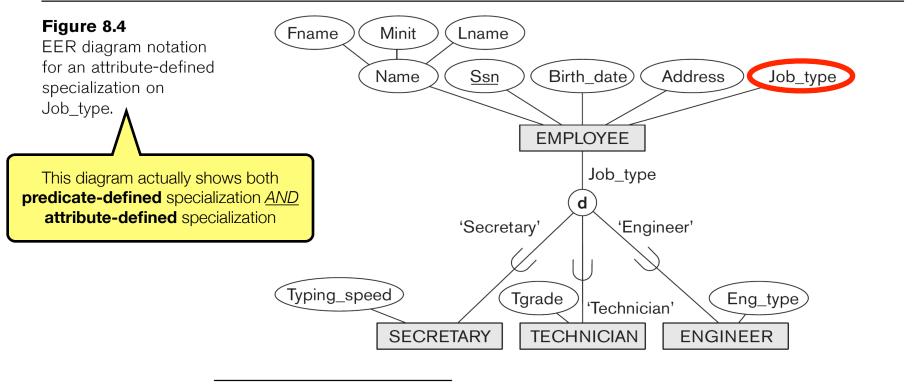# Constraints and Characteristics of Specialization and Generalization Hierarchies

- Constraints that apply to a single **specialization** or a single **generalization**

  - How to deal with?

- Differences between specialization/generalization **lattices** and **hierarchies**

- **Continued…**

Constraints on Specialization and Generalization

- May be several or one subclass

- Determine entity subtype:

  - **Predicate-defined** (or **condition-defined**) **subclasses**
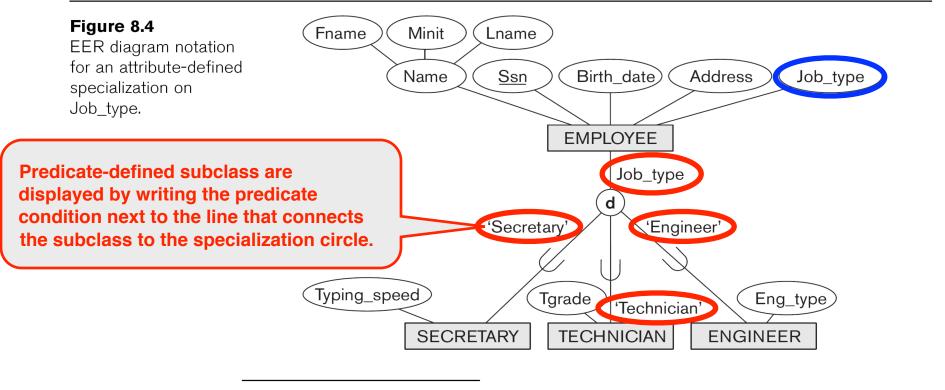
  - **Attribute-defined specialization**

  - **User-defined**

Constraints on Specialization and Generalization

- May be several or one subclass

- How to determine entity subtype

  - **Predicate-defined** (or **condition-defined**) **subclasses**

Figure 8.4
EER diagram notation for an attribute-defined specialization on Job_type.
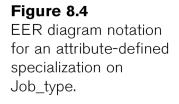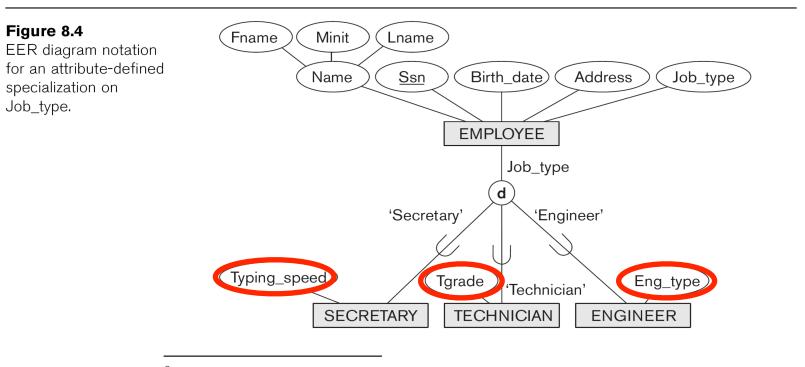
This diagram actually shows both **predicate-defined** specialization *AND* **attribute-defined** specialization

[6]Such an attribute is called a *discriminator* in UML terminology.

Constraints on Specialization and Generalization

- May be several or one subclass

- Determine entity subtype:

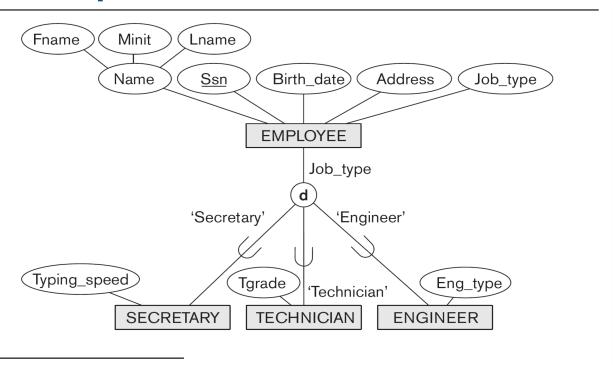   - **Predicate-defined** (or **condition-defined**) **subclasses**

Figure 8.4
EER diagram notation for an attribute-defined specialization on Job_type.

Predicate-defined subclass are displayed by writing the predicate condition next to the line that connects the subclass to the specialization circle.

[6]Such an attribute is called a *discriminator* in UML terminology.

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# Constraints on Specialization and Generalization

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- Determine entity subtype:

  - **Predicate-defined** (or **condition-defined**) **subclasses**
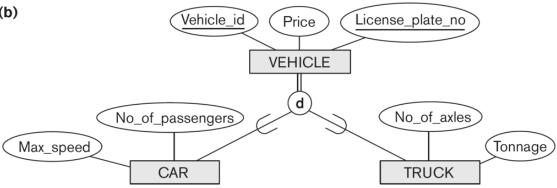
  - **Attribute-defined specialization**

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Constraints on Specialization and Generalization

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- **Disjointness constraint**

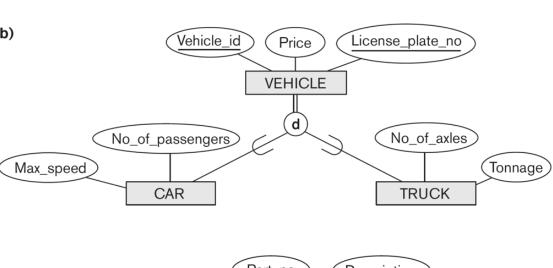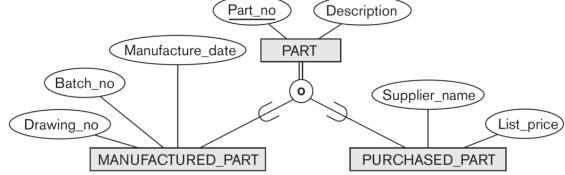 - Specifies that the subclasses of the specialization must be disjoint

(b)

- **Disjointness constraint**

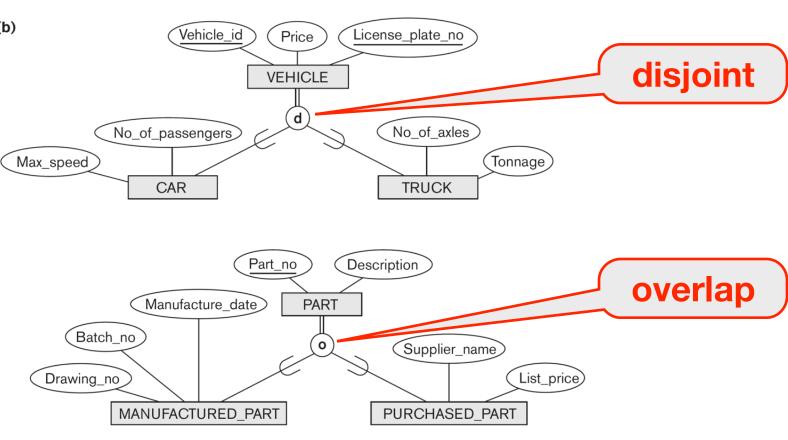 - Specifies that the subclasses of the specialization must be disjoint

(b)
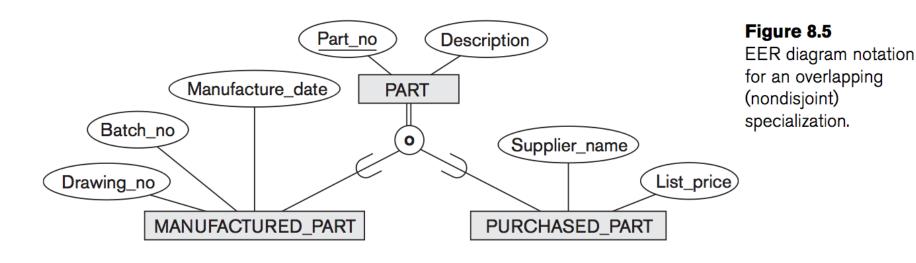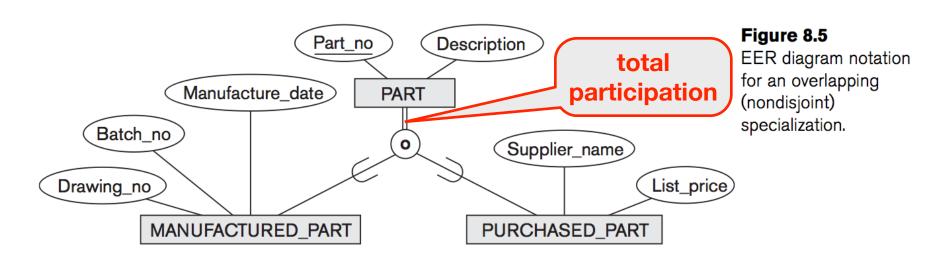
- ## Disjointness constraint
  - Specifies that the subclasses of the specialization must be disjoint

- **Completeness**, or **totalness**, **constraint** (for subtype)
  - May be **total** or **partial**
- Disjointness and completeness constraints are independent

Figure 8.5
EER diagram notation for an overlapping (nondisjoint) specialization.

[7]The notation of using single or double lines is similar to that for partial or total participation of an entity type in a relationship type, as described in Chapter 7.

Constraints on Specialization and Generalization (cont'd.)

- **Completeness** (or **totalness**) **constraint**
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EER diagram notation for an overlapping (nondisjoint) specialization.

total participation

[7]The notation of using single or double lines is similar to that for partial or total participation of an entity type in a relationship type, as described in Chapter 7.

Specialization and Generalization Hierarchies and Lattices
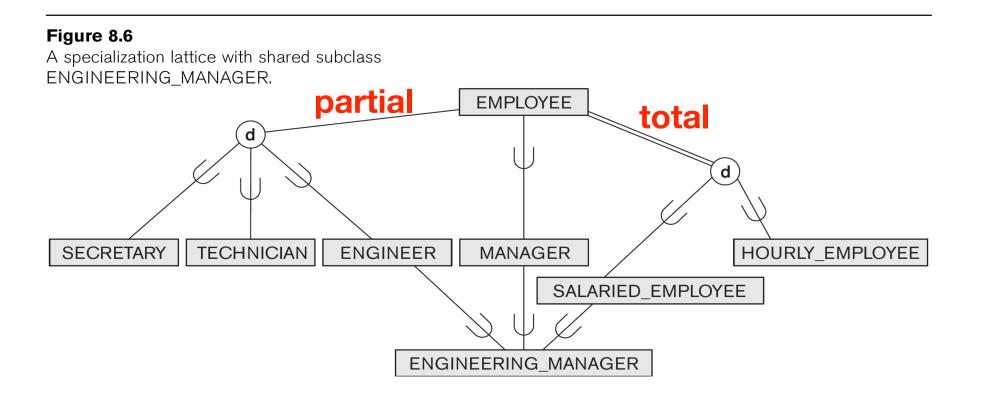
- **Specialization hierarchy**

  - Every subclass participates as a subclass in only one class/subclass relationship

  - Results in a **tree structure** or **strict hierarchy**

- **Specialization lattice**

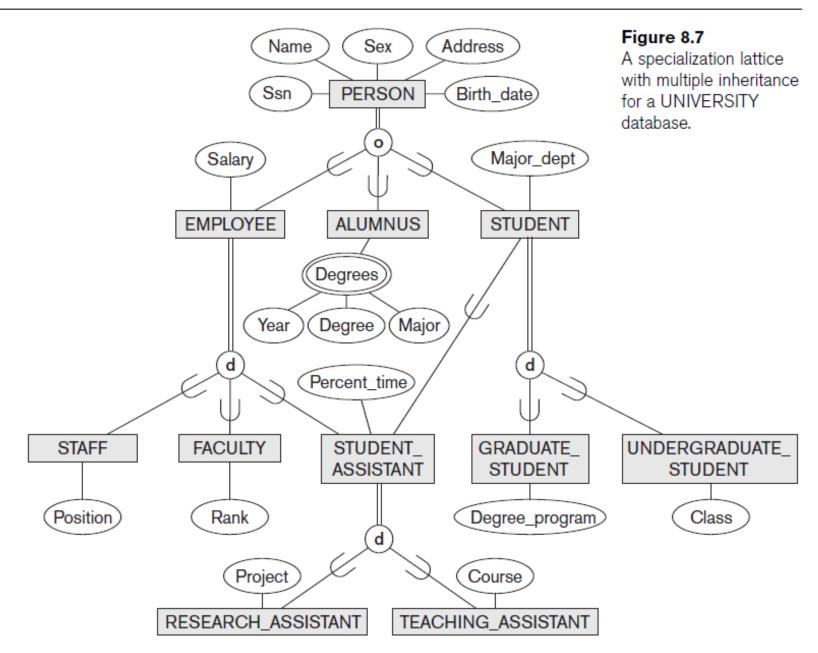 - Subclass can be a subclass in more than one class/subclass relationship (i.e. **multiple inheritance**)

Figure 8.6

A specialization lattice with shared subclass
ENGINEERING_MANAGER.

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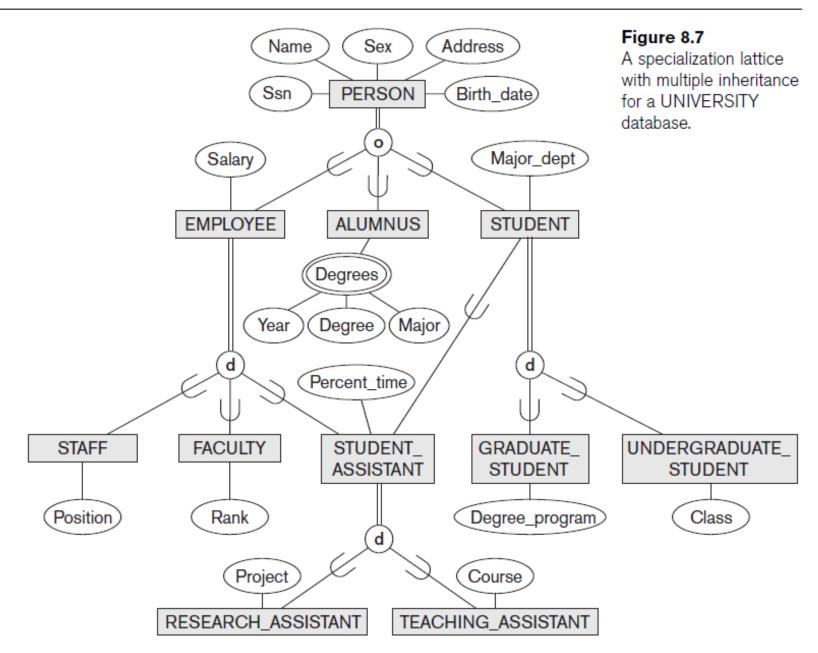
- **Multiple inheritance**

    - 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

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

Utilizing Specialization and Generalization in Refining Conceptual Schemas

- **Specialization process**

  - **Top-down** conceptual refinement process

  - Start with entity type then define subclasses by successive specialization

- **Generalization process**

  - **Bottom-up** conceptual synthesis

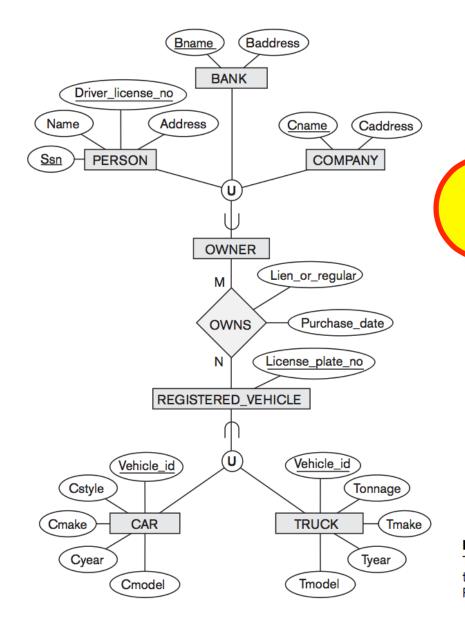 - Involves generalization rather than specialization

- **Union type** or a **category**

  - Represents a single superclass/subclass relationship with more than one superclass (disjoint, not overlap)

  - 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

Modeling of UNION Types Using Categories

Figure 8.8
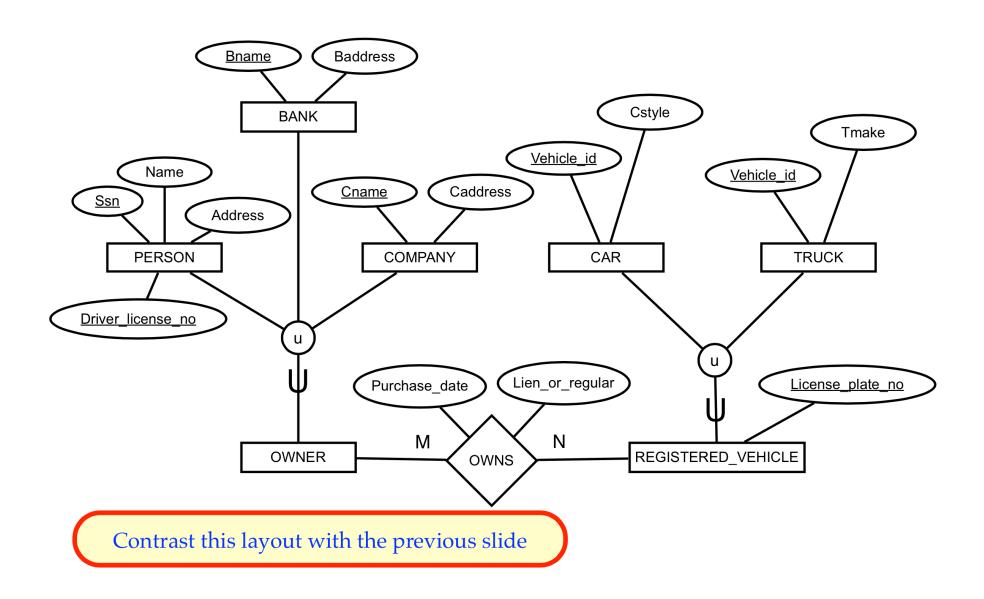Two categories (union types): OWNER and REGISTERED_VEHICLE.

> ! The textbook layout for this diagram may be confusing. Note that OWNER subtype inheritance pitchfork points *up,* but REGISTERED_VEHICLE subtype inheritance pitchfork points *down*.

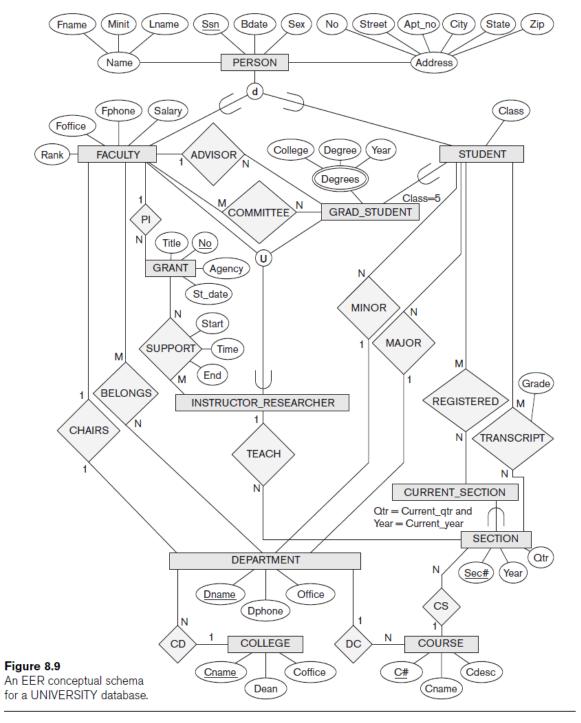Contrast this layout with the previous slide

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

- The UNIVERSITY Database Example

  - Students and their majors

  - Transcripts, and registration

  - University's course offerings

Figure 8.9
An EER conceptual schema for a UNIVERSITY database.

- If all the subclasses of a specialization/generalization have few specific attributes and no specific relationships, then…

  - Can be merged into the superclass (not enough specificity)

  - Replace with one or more type attributes that specify the subclass or subclasses to which each entity belongs

- Union types and categories should generally be avoided

  - Opinion

- Choice of:

  - Disjoint/overlapping

  - Total/partial constraints on spec. vs. gen are…

  - Driven by rules in mini-world being modeled

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

Formal Definitions for the EER Model Concepts

- **Specialization**
  - Set of subclasses that have same superclass

- **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*

- **Attribute-defined**

- **User-defined**

  - Subclass that is not defined by a predicate

- **Category**
  - Class that is a subset of the union of n defining superclasses

- **Relationship type**
  - Any class can participate in a relationship

- END for Midterm

Examples of Other Notations

- **UML**
  - OOP

- **Ontologies and the Semantic Web**
  - RDF / OWL

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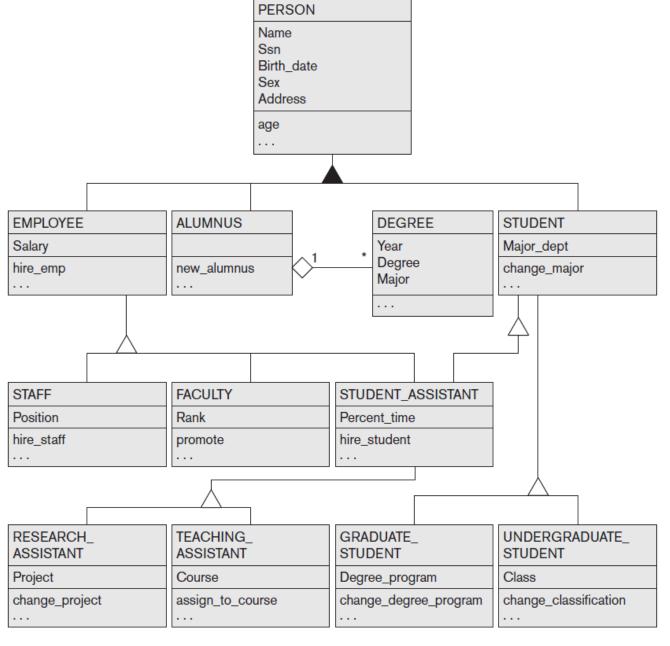   - Subclasses (leaf nodes)

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

- **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

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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**

  - 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
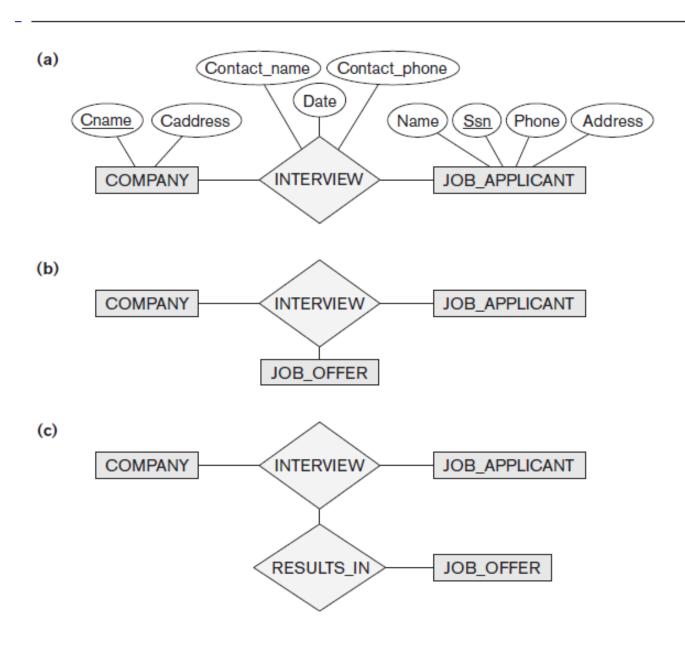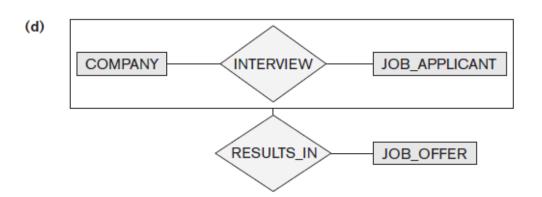
Aggregation

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.
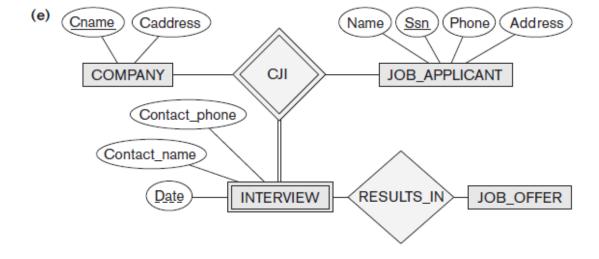
UTD

Figure 8.11
Aggregation. (a) The relation-ship type INTERVIEW. (b) Including JOB_OFFER in a ternary relationship type (incorrect). (c) Having the RESULTS_IN relationship par-ticipate 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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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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Ontologies and the Semantic Web

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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