

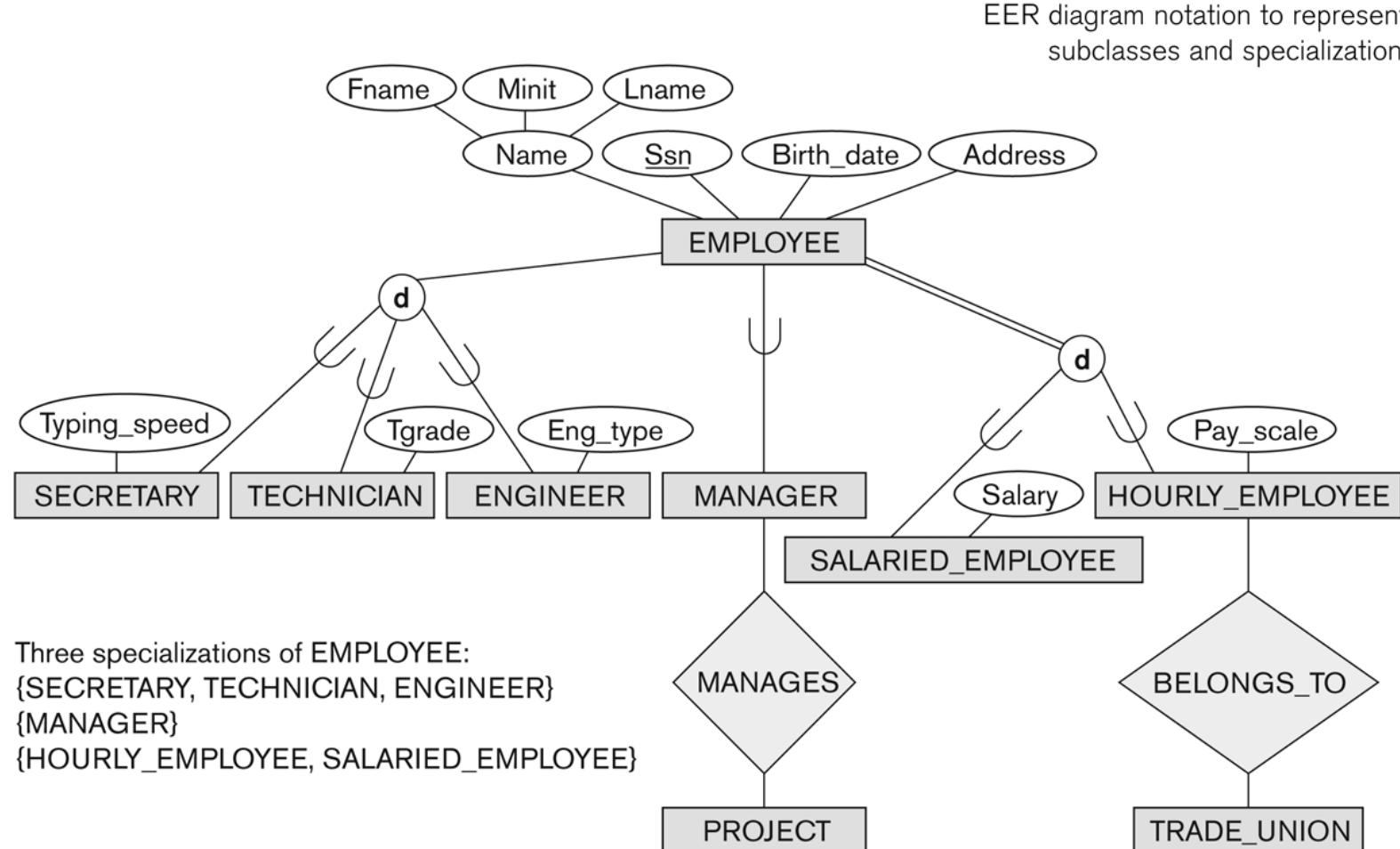
# CHAPTER 4

## Enhanced Entity-Relationship (EER) Modeling

# Subclasses and Superclasses (1)

- An entity type may have additional meaningful subgroupings of its entities
  - Example: EMPLOYEE may be further grouped into:
    - SECRETARY, ENGINEER, TECHNICIAN, ...
      - Based on the EMPLOYEE's Job
    - MANAGER
      - EMPLOYEES who are managers (the role they play)
    - SALARIED\_EMPLOYEE, HOURLY\_EMPLOYEE
      - Based on the EMPLOYEE's method of pay
- EER diagrams extend ER diagrams to represent these additional subgroupings, called *subclasses* or *subtypes*

# Subclasses and Superclasses



# Subclasses and Superclasses (2)

- Each of these subgroupings is a subset of EMPLOYEE entities
- Each is called a subclass of EMPLOYEE
- EMPLOYEE is the superclass for each of these subclasses
- These are called superclass/subclass relationships:
  - EMPLOYEE/SECRETARY
  - EMPLOYEE/TECHNICIAN
  - EMPLOYEE/MANAGER
  - ...
- These are also called IS-A relationships
  - SECRETARY IS-A EMPLOYEE, TECHNICIAN IS-A EMPLOYEE, ....

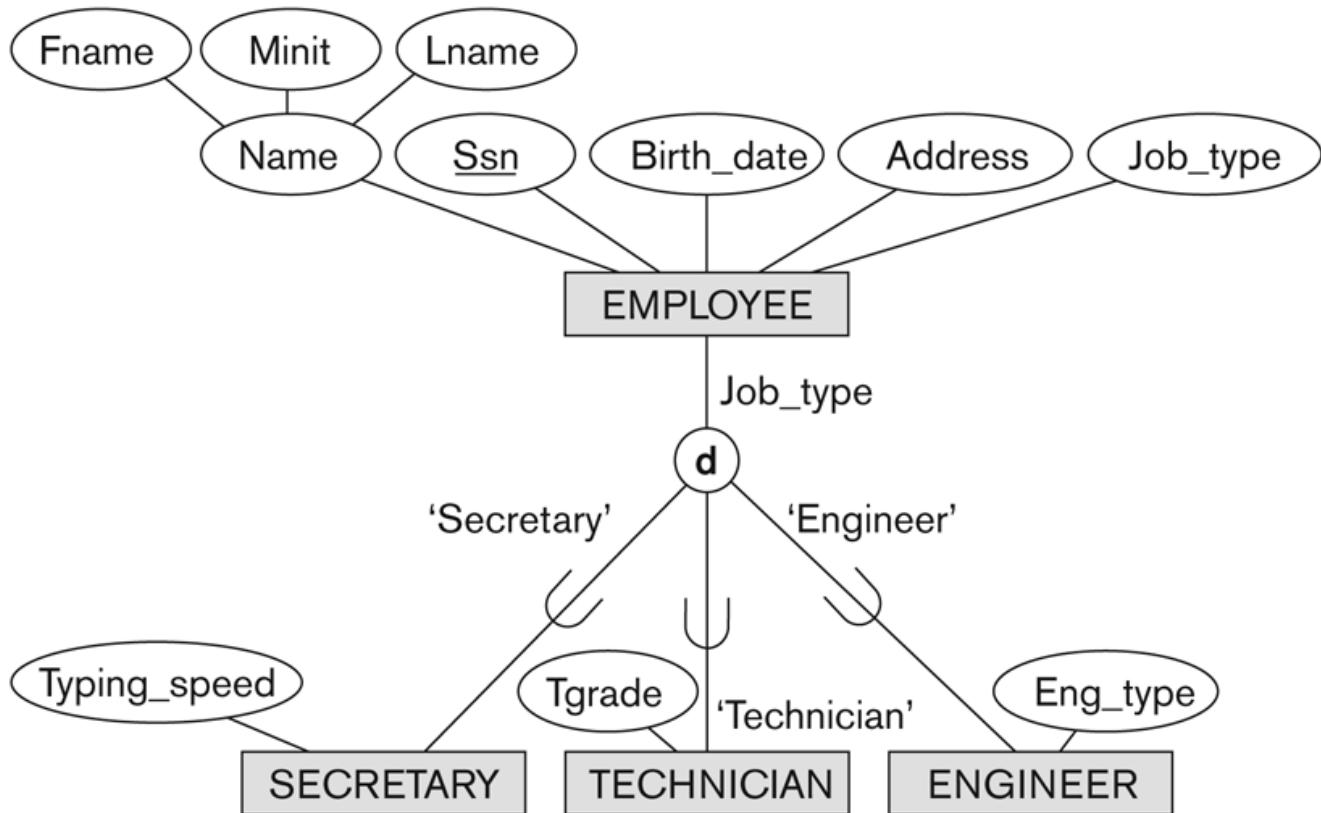
# Subclasses and Superclasses (4)

- Examples:
  - A salaried employee who is also an engineer belongs to the two subclasses:
    - ENGINEER, and
    - SALARIED\_EMPLOYEE
  - A salaried employee who is also an engineering manager belongs to the three subclasses:
    - MANAGER,
    - ENGINEER, and
    - SALARIED\_EMPLOYEE
- It is not necessary that every entity in a superclass be a member of some subclass

# Representing Specialization in EER Diagrams

**Figure 4.4**

EER diagram notation for an attribute-defined specialization on Job\_type.



# Attribute Inheritance in Superclass / Subclass Relationships

- An entity that is member of a subclass *inherits*
  - All attributes of the entity as a member of the superclass
  - All relationships of the entity as a member of the superclass
- Example:
  - In the previous slide, SECRETARY (as well as TECHNICIAN and ENGINEER) inherit the attributes Name, SSN, ..., from EMPLOYEE
  - Every SECRETARY entity will have values for the inherited attributes

# Specialization (1)

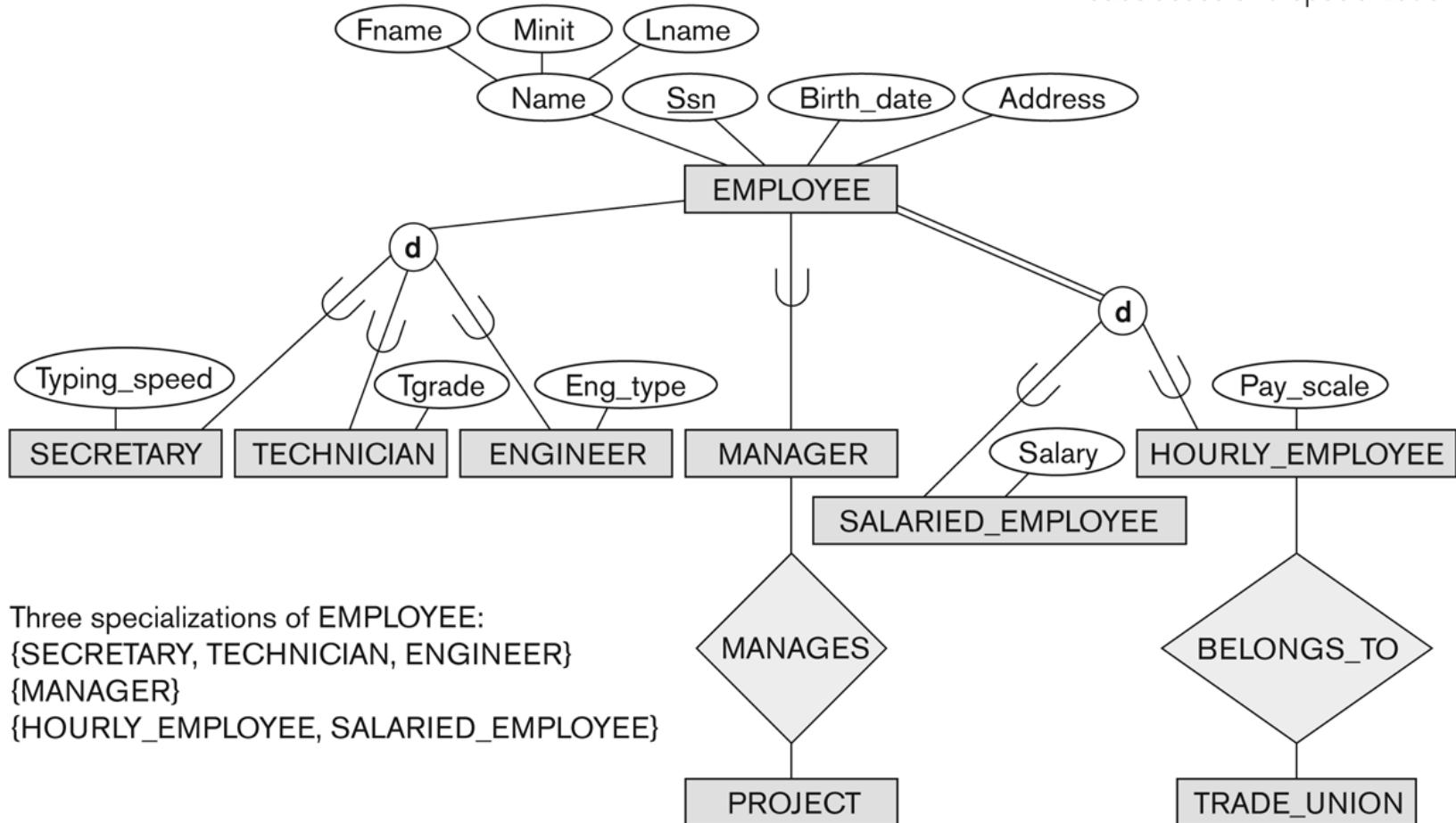
- Specialization is the process of defining a set of subclasses of a superclass
- The set of subclasses is based upon some distinguishing characteristics of the entities in the superclass
  - Example: {SECRETARY, ENGINEER, TECHNICIAN} is a specialization of EMPLOYEE based upon *job type*.
  - Example: MANAGER *is a specialization of EMPLOYEE based on the role the employee plays*
    - May have several specializations of the same superclass

# Specialization (2)

- Example: Another specialization of EMPLOYEE based on *method of pay* is {SALARIED\_EMPLOYEE, HOURLY\_EMPLOYEE}.
  - Superclass/subclass relationships and specialization can be diagrammatically represented in EER diagrams
  - Attributes of a subclass are called *specific* or *local* attributes.
    - For example, the attribute TypingSpeed of SECRETARY
  - The subclass can also participate in specific relationship types.
    - For example, a relationship BELONGS\_TO of HOURLY\_EMPLOYEE

# Specialization (3)

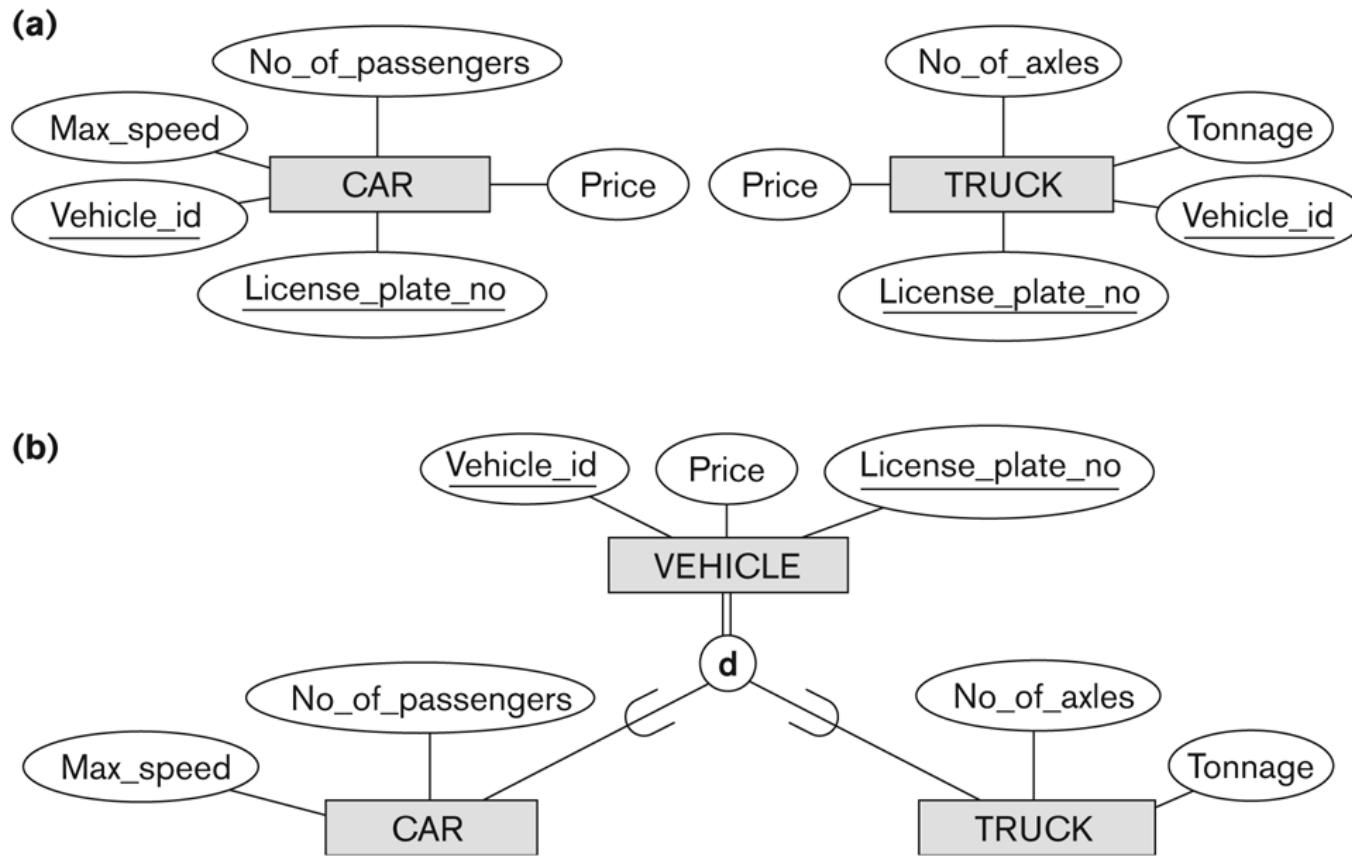
**Figure 4.1**  
EER diagram notation to represent subclasses and specialization.



# Generalization

- Generalization is the reverse of the specialization process
- Several classes with common features are generalized into a superclass:
  - original classes become its subclasses
- Example: CAR, TRUCK generalized into VEHICLE;
  - both CAR, TRUCK become subclasses of the superclass VEHICLE.
  - We can view {CAR, TRUCK} as a specialization of VEHICLE
  - Alternatively, we can view VEHICLE as a generalization of CAR and TRUCK

# Generalization (2)



**Figure 4.3**  
Generalization. (a) Two entity types, CAR and TRUCK.  
(b) Generalizing CAR and TRUCK into the superclass VEHICLE.

# Generalization and Specialization (1)

- Diagrammatic notations are sometimes used to distinguish between generalization and specialization
  - Arrow pointing to the generalized superclass represents a generalization
  - Arrows pointing to the specialized subclasses represent a specialization
  - We *do not use* this notation because it is often subjective as to which process is more appropriate for a particular situation
  - We advocate not drawing any arrows

# Generalization and Specialization (2)

- Data Modeling with Specialization and Generalization
  - A superclass or subclass represents a collection (or set or grouping) of entities
  - It also represents a particular *type of entity*
  - Shown in rectangles in EER diagrams (as are entity types)
  - We can call all entity types (and their corresponding collections) **classes**, whether they are entity types, superclasses, or subclasses

# Types of Specialization

- Predicate-defined ( or condition-defined) : based on some predicate. E.g., based on value of an attribute, say, Job-type, or Age.
- Attribute-defined: shows the name of the attribute next to the line drawn from the superclass toward the subclasses (see Fig. 4.1)
- User-defined: membership is defined by the user on an entity by entity basis

# Constraints on Specialization and Generalization (1)

- If we can determine exactly those entities that will become members of each subclass by a condition, the subclasses are called predicate-defined (or condition-defined) subclasses
  - Condition is a constraint that determines subclass members
  - Display a predicate-defined subclass by writing the predicate condition next to the line attaching the subclass to its superclass

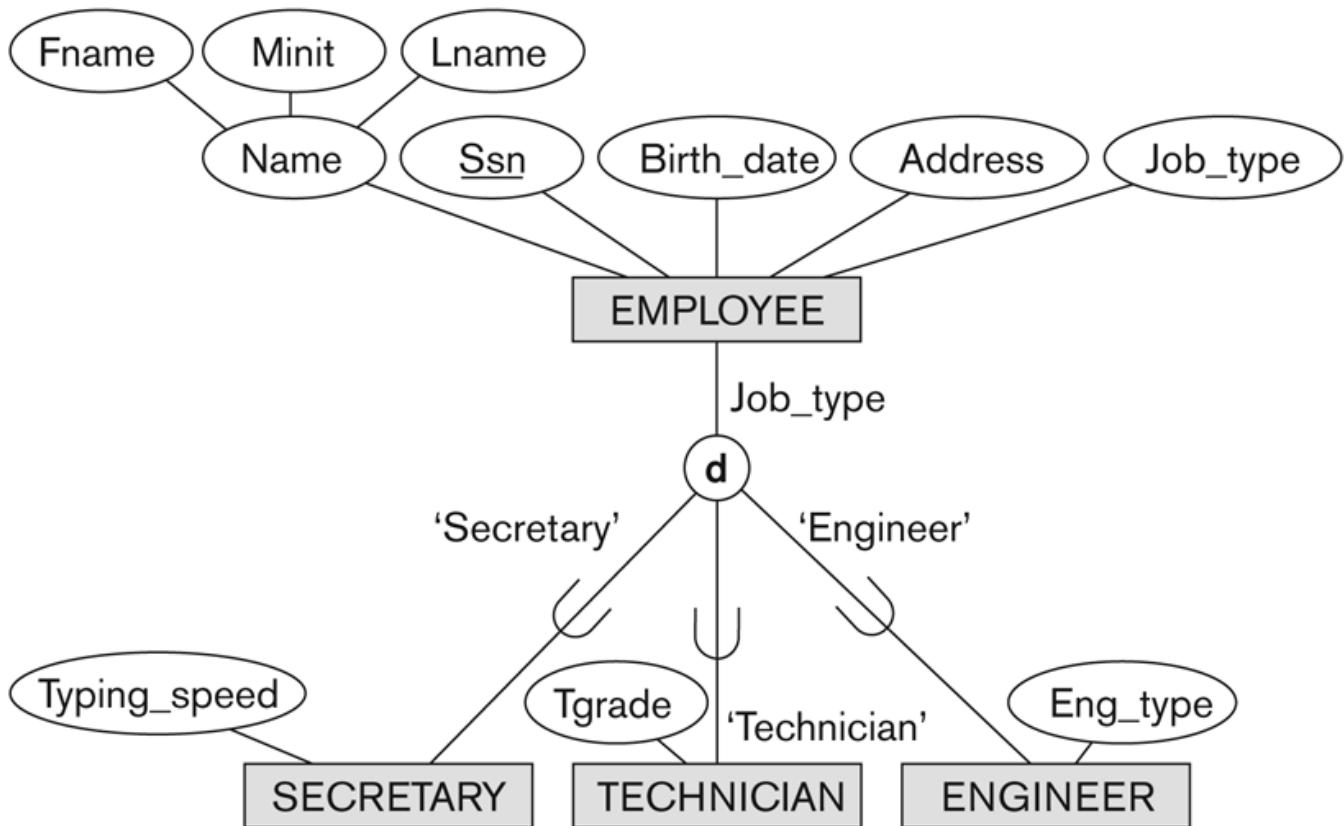
# Constraints on Specialization and Generalization (2)

- If all subclasses in a specialization have membership condition on same attribute of the superclass, specialization is called an attribute-defined specialization
  - Attribute is called the defining attribute of the specialization
  - Example: JobType is the defining attribute of the specialization {SECRETARY, TECHNICIAN, ENGINEER} of EMPLOYEE
- If no condition determines membership, the subclass is called user-defined
  - Membership in a subclass is determined by the database users by applying an operation to add an entity to the subclass
  - Membership in the subclass is specified individually for each entity in the superclass by the user

# Displaying an attribute-defined specialization in EER diagrams

**Figure 4.4**

EER diagram notation for an attribute-defined specialization on Job\_type.



# Constraints on Specialization and Generalization (3)

- Two basic constraints can apply to a specialization/generalization:
  - Disjointness Constraint:
  - Completeness Constraint:

# Constraints on Specialization and Generalization (4)

- Disjointness Constraint:
  - Specifies that the subclasses of the specialization must be *disjoint*:
    - an entity can be a member of at most one of the subclasses of the specialization
  - Specified by **d** in EER diagram
  - If not disjoint, specialization is *overlapping*:
    - that is the same entity may be a member of more than one subclass of the specialization
  - Specified by **o** in EER diagram

# Constraints on Specialization and Generalization (5)

- Completeness (Exhaustiveness) Constraint:
  - *Total* specifies that every entity in the superclass must be a member of some subclass in the specialization/generalization
  - Shown in EER diagrams by a **double line**
  - *Partial* allows an entity not to belong to any of the subclasses
  - Shown in EER diagrams by a single line

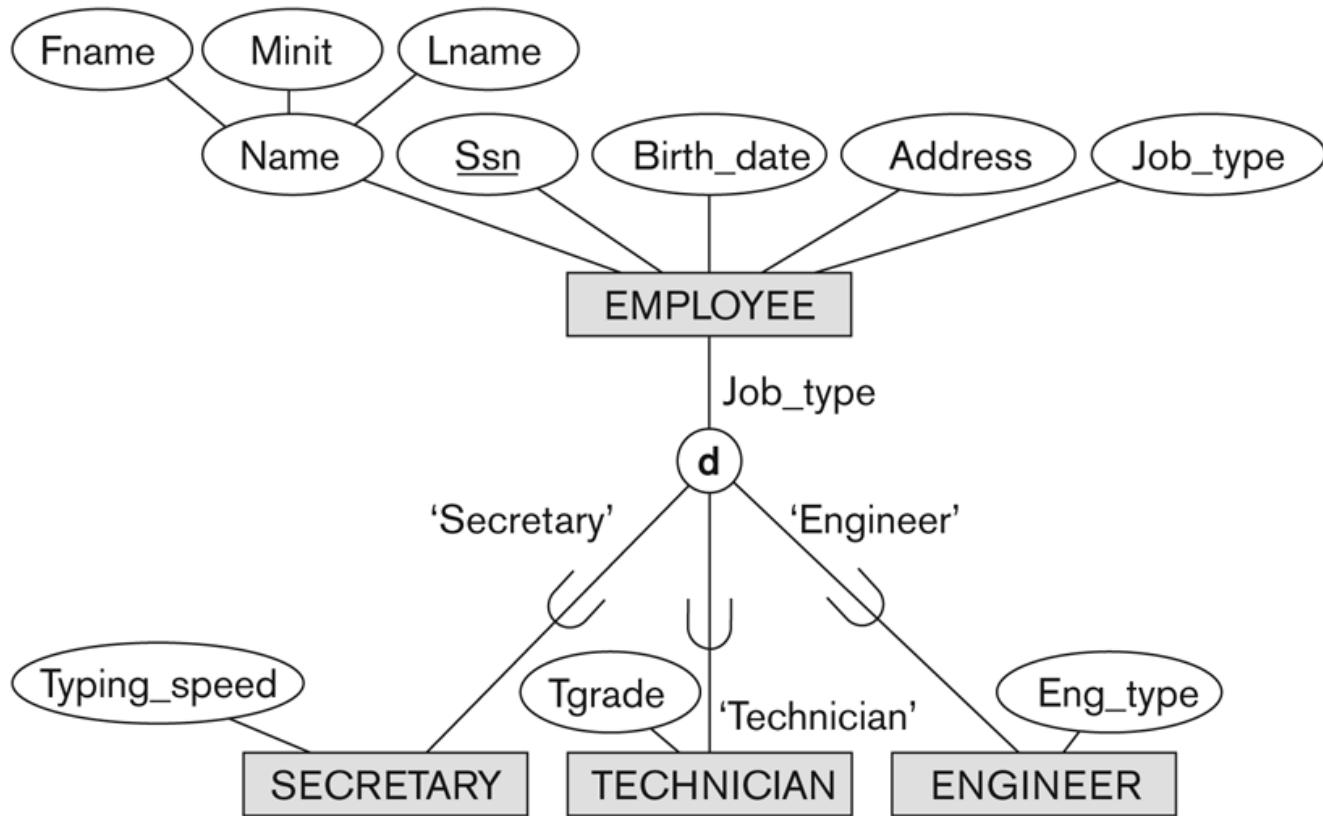
# Constraints on Specialization and Generalization (6)

- Hence, we have four types of specialization/generalization:
  - Disjoint, total
  - Disjoint, partial
  - Overlapping, total
  - Overlapping, partial
- Note: Generalization usually is total because the superclass is derived from the subclasses.

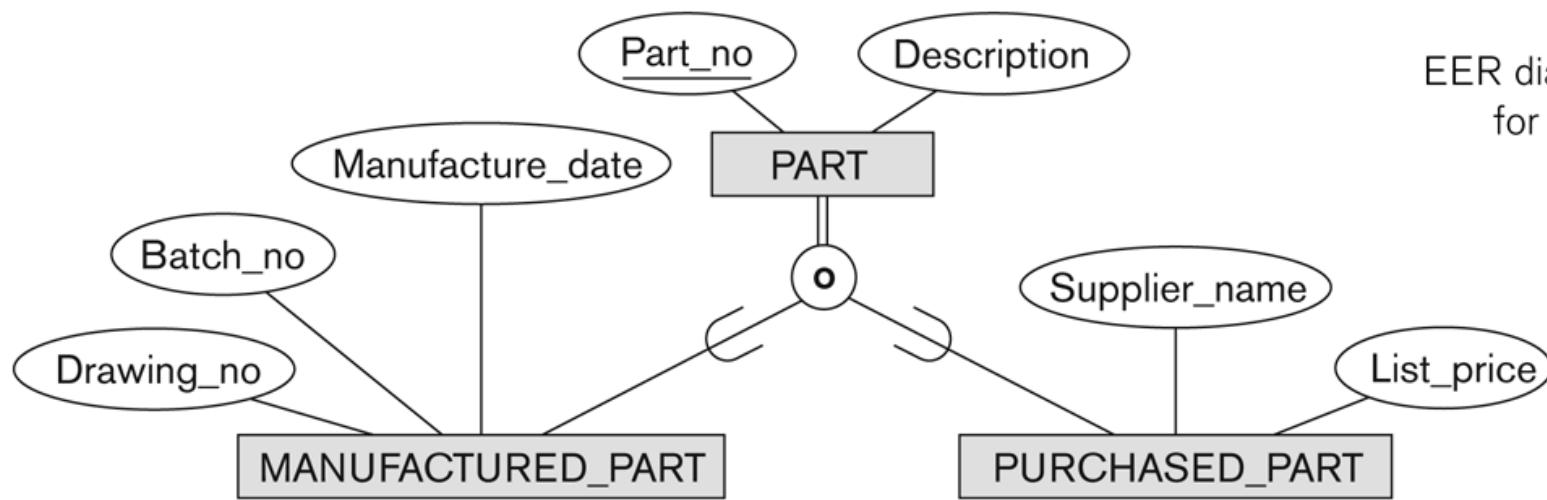
# Example of disjoint partial Specialization

**Figure 4.4**

EER diagram notation for an attribute-defined specialization on Job\_type.



# Example of overlapping total Specialization



**Figure 4.5**

EER diagram notation  
for an overlapping  
(nondisjoint)  
specialization.