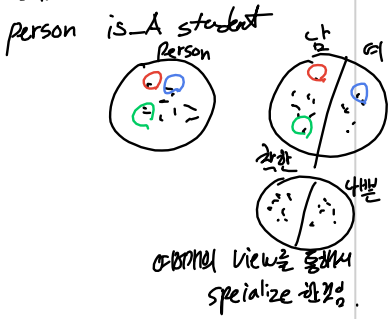
1 ER-supplementary. Enhanced Entity-Relationship (EER) Model

1.1 Contents

- EER stands for Enhanced ER or Extended ER
- EER Model Concepts
  - Includes all modeling concepts of basic ER
  - Additional concepts:
    - subclasses/superclasses
    - specialization/generalization
    - categories (UNION types)
  - These are fundamental to conceptual modeling
- The additional EER concepts are used to model applications more completely and more accurately
  - EER includes some object-oriented concepts, such as inheritance



1.2 Subclasses and Superclasses

- 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
    - 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

1.3 Subclasses and Superclasses

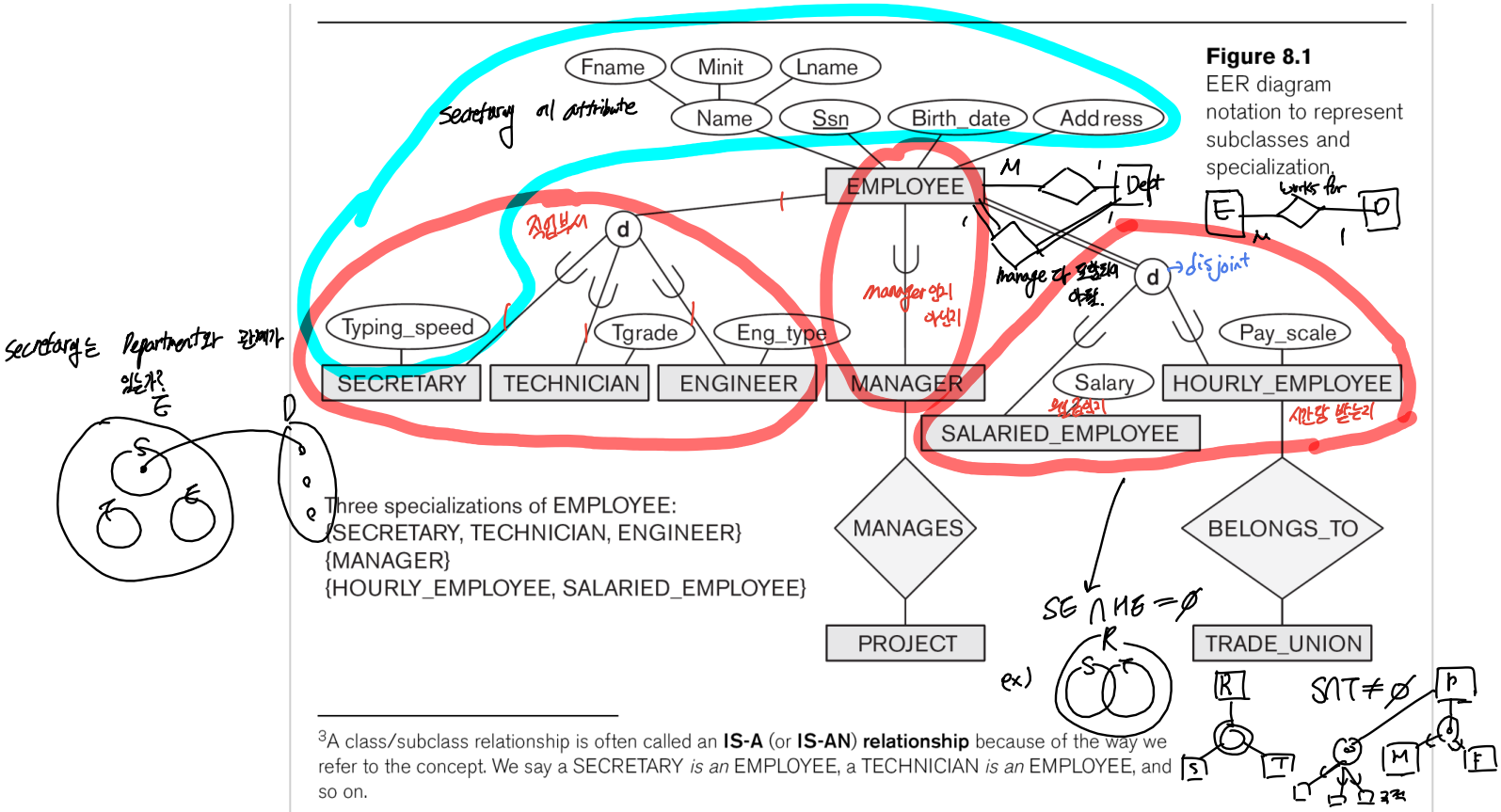


Figure 8.1
EER diagram notation to represent subclasses and specialization

[3] A class/subclass relationship is often called an **IS-A** (or **IS-AN**) **relationship** because of the way we refer to the concept. We say a SECRETARY *is an* EMPLOYEE, a TECHNICIAN *is an* EMPLOYEE, and so on.

1.4 Subclasses and Superclasses

- 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
  - ...

1.5 Subclasses and Superclasses

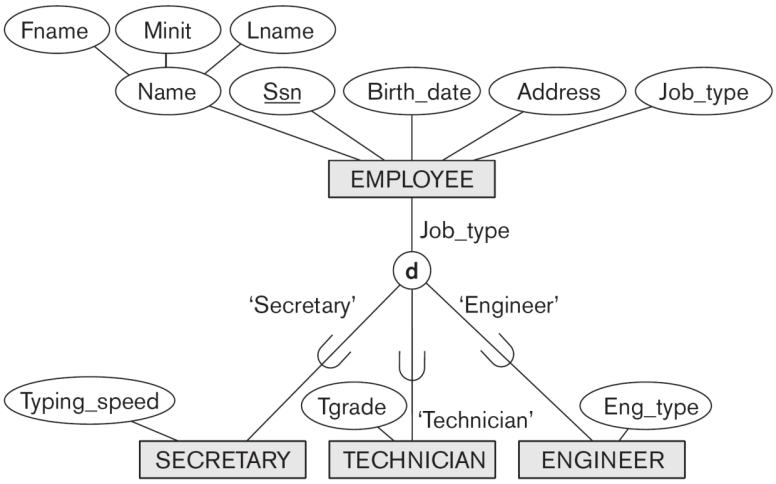
- These are also called IS-A relationships
  - SECRETARY IS-A EMPLOYEE, TECHNICIAN IS-A EMPLOYEE, ...
- Note: An entity that is member of a subclass represents the same real-world entity as some member of the superclass:
  - The subclass member is the same entity in a distinct specific role
  - **An entity cannot exist in the database merely by being a member of a subclass**; it must also be a member of the superclass
  - A member of the superclass can be optionally included as a member of any number of its subclasses

1.6 Subclasses and Superclasses

- 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

1.7 Representing Specialization in EER Diagrams

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



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

1.8 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

1.9 Specialization

- 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.
    - May have several specializations of the same superclass

1.10 Instance of a Specialization

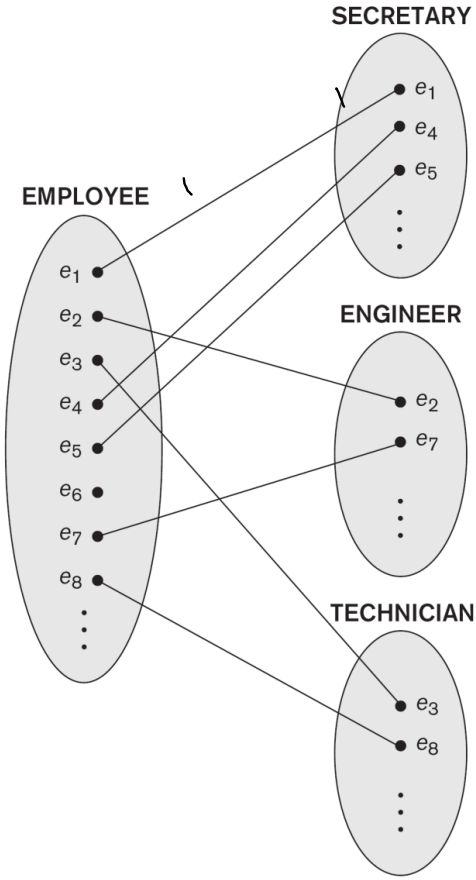


Figure 8.2
Instances of a specialization.

1.11 Specialization

- 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

1.12 Specialization

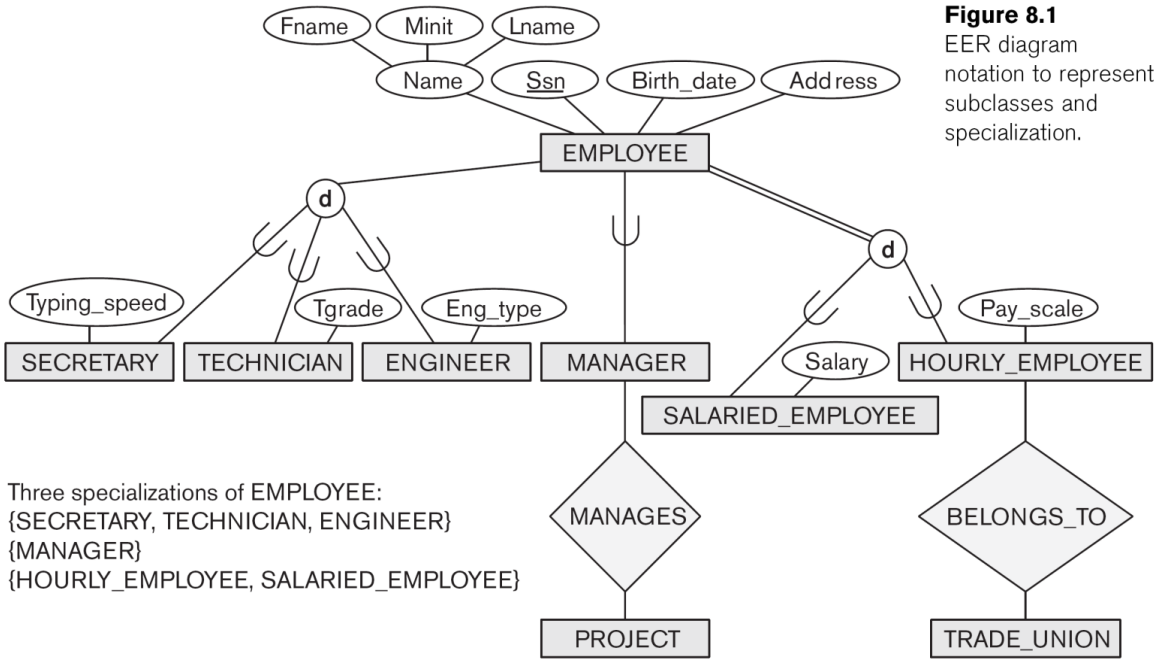


Figure 8.1
EER diagram notation to represent subclasses and specialization.

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1.13 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

1.14 Generalization

개별 entity들에서 공통점을 찾아 하나의 서브클래스-슈퍼클래스 관계로 만드는것

disjoint는 하나의 인스턴스가 하나의 서브클래스 entity 값만 가져야하고

overlapping은 하나의 인스턴스가 여러개의 서브클래스 값을 가질 수 있는 것이다.

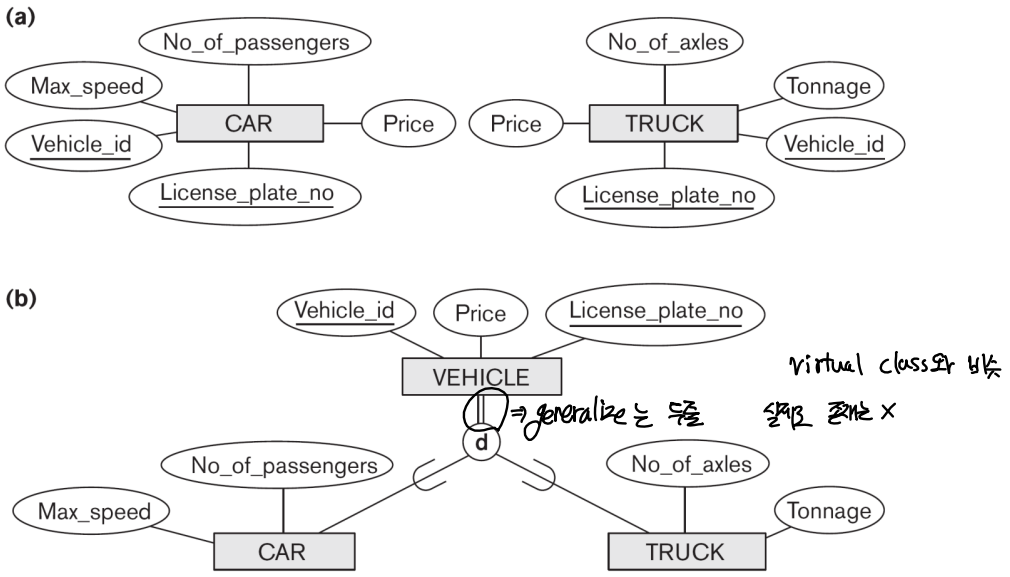


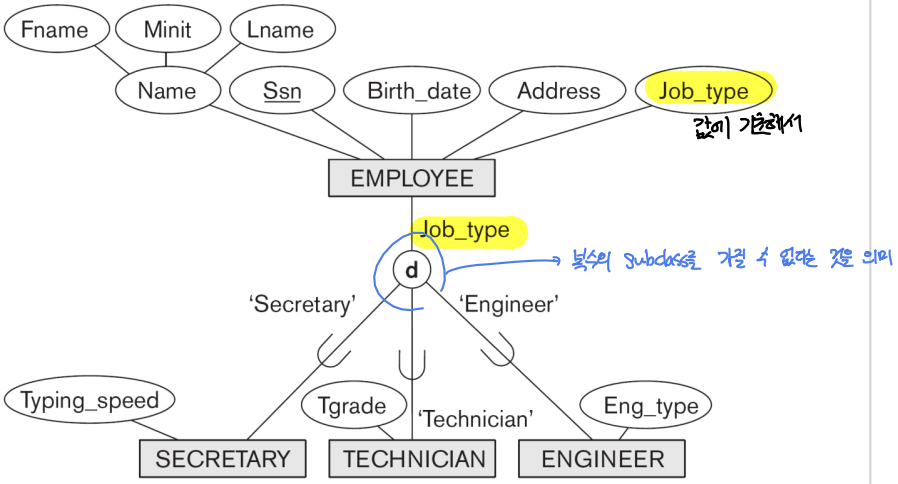
Figure 8.3
Generalization. (a) Two entity types, CAR and TRUCK. (b) Generalizing CAR and TRUCK into the superclass VEHICLE.

virtual class와 비슷
⇒ generalize는 두줄 실제로 존재는 X

Total은 선이 두개 (=) Partial은 선이 하나(-) 이다.
Total은 슈퍼클래스가 모든 서브클래스를 가져야하는 것을 뜻함.
Partial은 선택적인 것을 뜻함.

1.15 Example of disjoint partial Specialization

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



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

1.16 Example of overlapping total Specialization

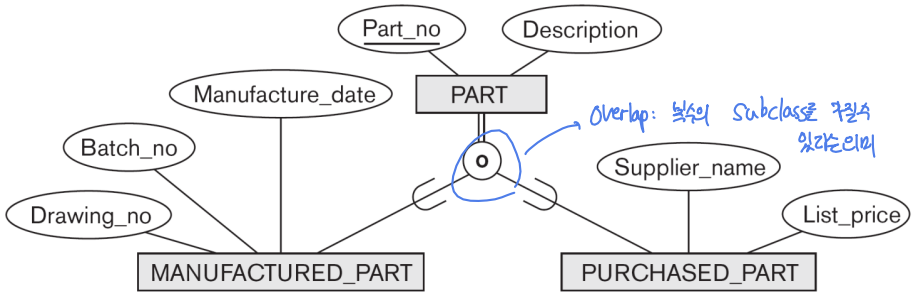


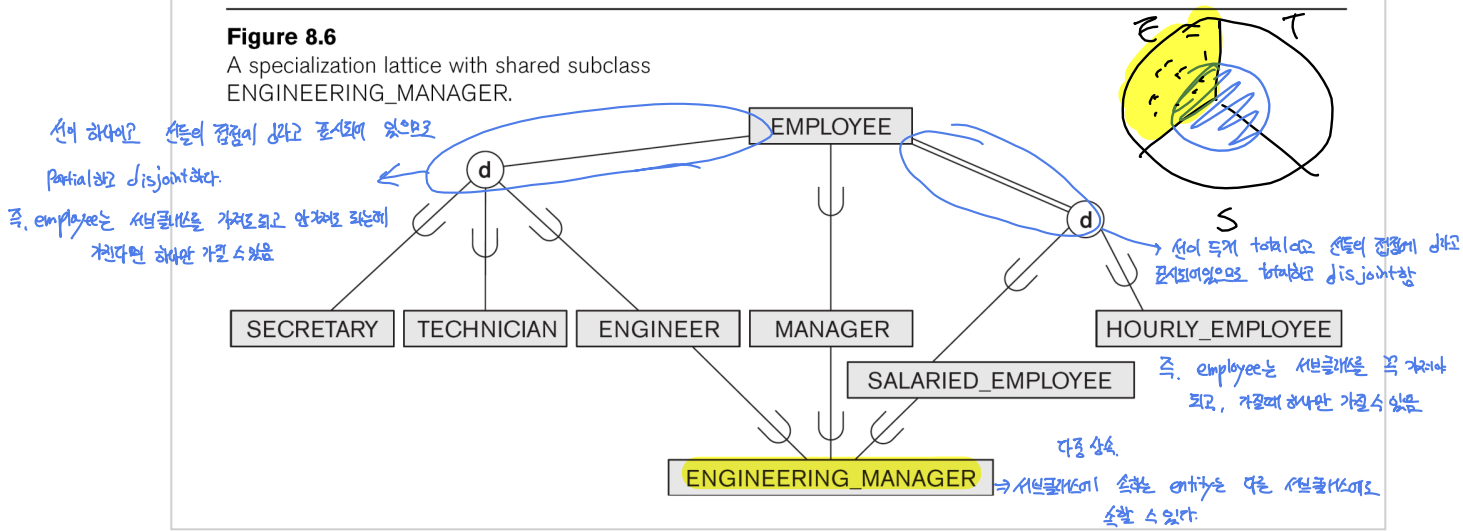
Figure 8.5
EER diagram notation for an overlapping (nondisjoint) specialization.

[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.

1.17 Multiple Inheritance: Shared Subclass "Engineering_Manager"

⇒ lattice

Figure 8.6
A specialization lattice with shared subclass ENGINEERING_MANAGER.



1.18 Specialization / Generalization Lattice Example (UNIVERSITY)

Partical order

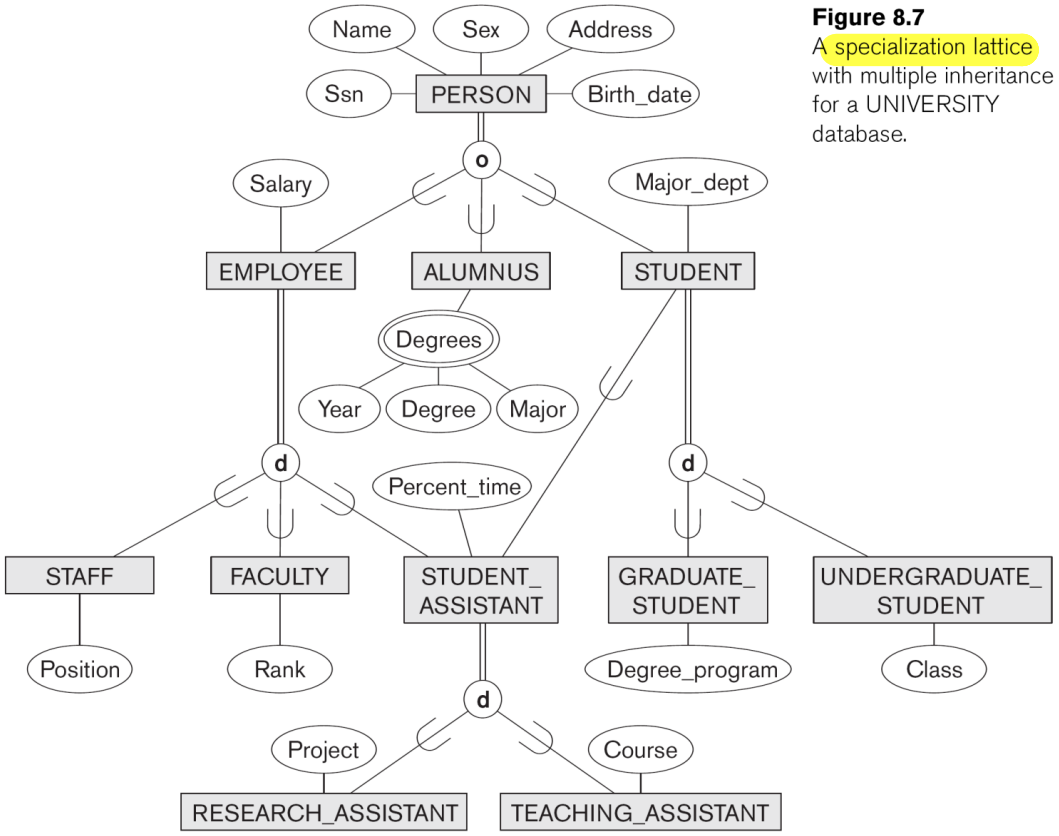


Figure 8.7
A specialization lattice with multiple inheritance for a UNIVERSITY database.

1.19 Categories (UNION TYPES)

- All of the superclass/subclass relationships we have seen thus far have a single superclass
- A shared subclass is a subclass in:
  - more than one distinct superclass/subclass relationships
  - each relationships has a single superclass
  - shared subclass leads to multiple inheritance
- In some cases, we need to model a single superclass/subclass relationship with more than one superclass
- Superclasses can represent different entity types
- Such a subclass is called a category or UNION TYPE

1.20 Categories (UNION TYPES)

- Example: In a database for vehicle registration, a vehicle owner can be a PERSON, a BANK (holding a lien on a vehicle) or a COMPANY.
  - A category (UNION type) called OWNER is created to represent a subset of the union of the three superclasses COMPANY, BANK, and PERSON
  - A category member must exist in at least one of its superclasses
- Difference from shared subclass, which is a:
  - subset of the intersection of its superclasses
  - shared subclass member must exist in all of its superclasses

1.21 Two categories (UNION types): OWNER, REGISTERED_VEHICLE

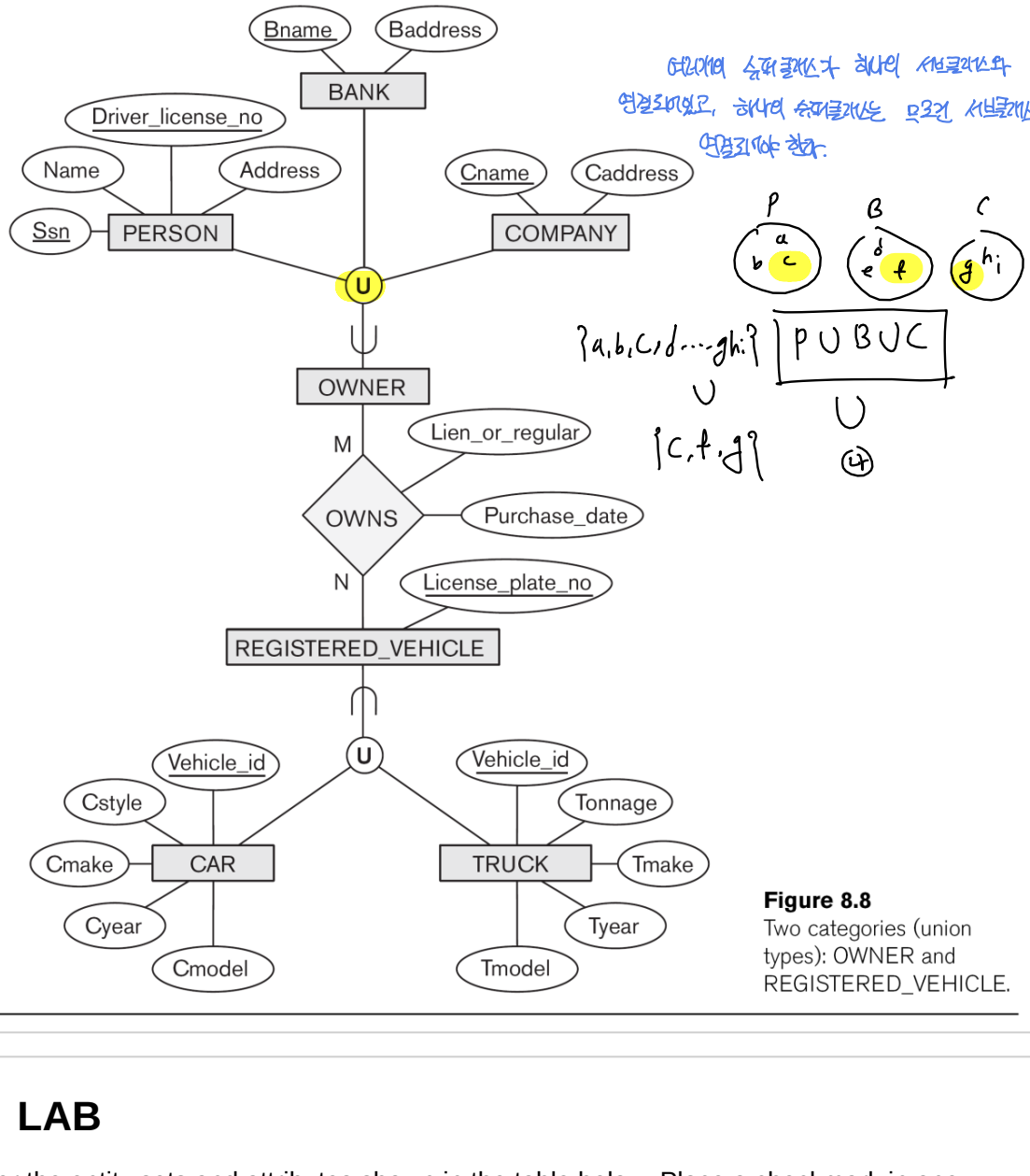


Figure 8.8
Two categories (union types): OWNER and REGISTERED_VEHICLE.

1.22 LAB

Consider the entity sets and attributes shown in the table below. Place a checkmark in one column in each row to indicate the relationship between the far left and right columns.

1. The left side has a relationship with the right side.
2. The right side is an attribute of the left side.
3. The left side is a specialization of the right side.
4. The left side is a generalization of the right side.

	Entity Set	(a) Has a Relationship with	(b) Has an Attribute that is	(c) Is a Specialization of	(d) Is a Generalization of	Entity Set or Attribute
1.	MOTHER					PERSON
2.	DAUGHTER					MOTHER
3.	STUDENT					PERSON
4.	STUDENT					Student_id
5.	SCHOOL					STUDENT
6.	SCHOOL					CLASS_ROOM
7.	ANIMAL					HORSE
8.	HORSE					Breed
9.	HORSE					Age
10.	EMPLOYEE					SSN
11.	FURNITURE					CHAIR
12.	CHAIR					Weight
13.	HUMAN					WOMAN
14.	SOLDIER					PERSON
15.	ENEMY_COMBATANT					PERSON

1.23 LAB

- Consider the BANK ER schema, and suppose that is is necessary to keep track of different types of ACCOUNTS (SAVINGS_ACCTS, CHECKING_ACCTS, TRUST,...) and LOANS (CAR_LOANS, HOME_LOANS, PERSONAL, ...).
- Suppose that is is also desirable to keep track of each account's TRANSACTIONs (deposits, withdrawals, checks,...) and each loan's PAYMENTs;
- both of these include the amount, date, time, ...
- Modify the BANK schema, using EER concepts of specialization and generalization.

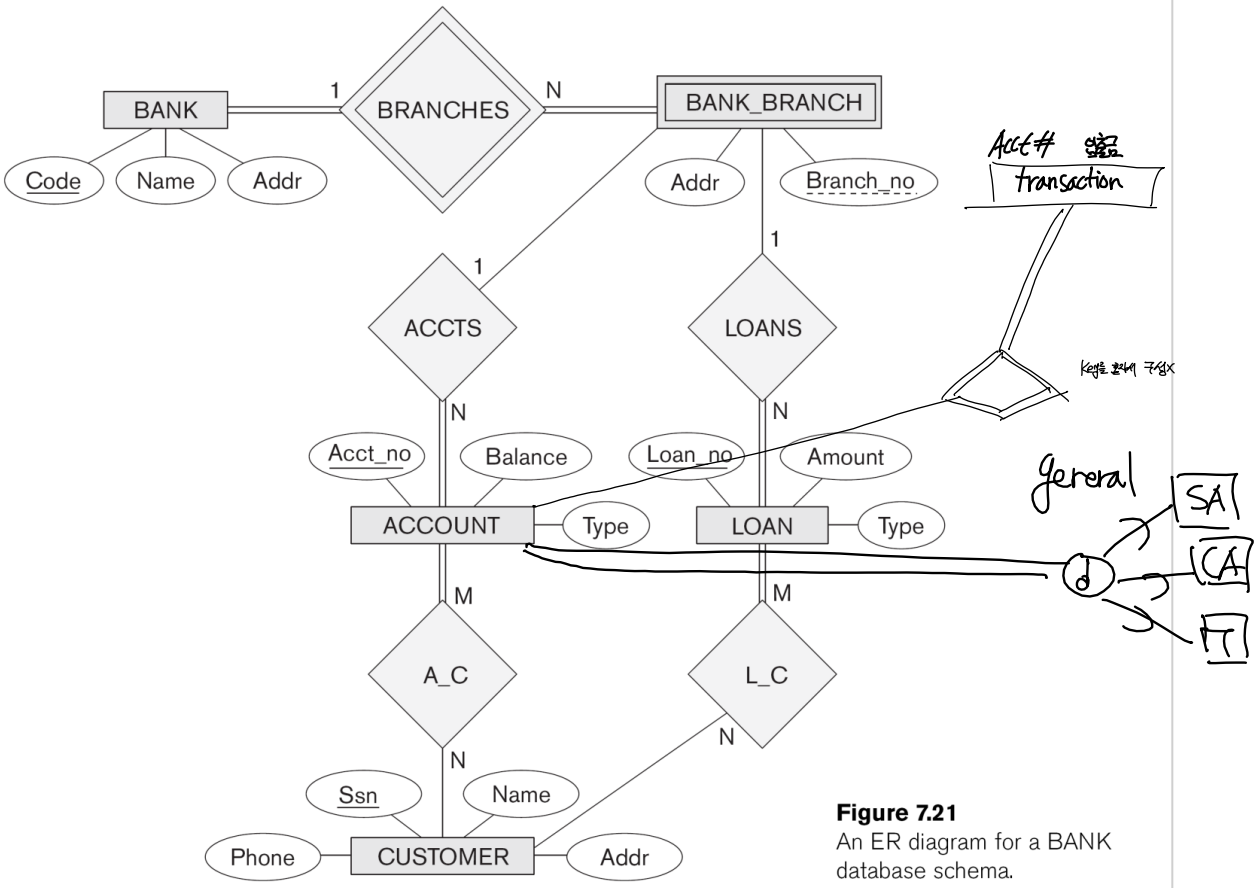


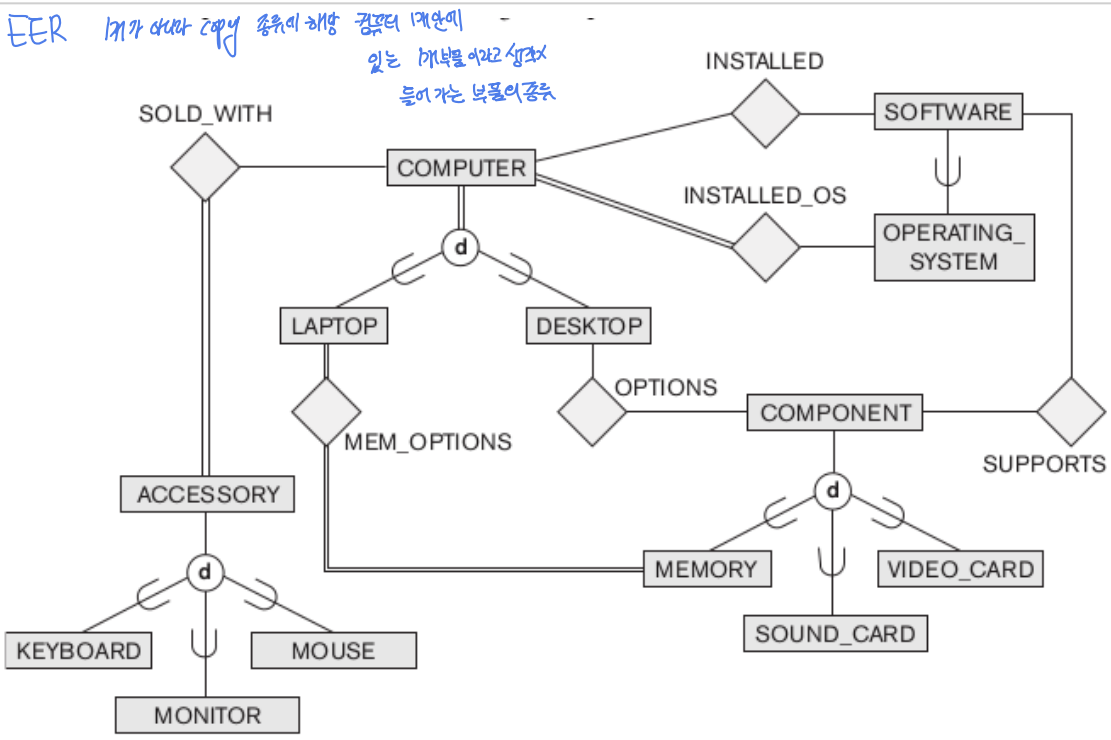
Figure 7.21
An ER diagram for a BANK database schema.

1.24 LAB

Design an EER diagram that describes computer systems at a company.

Hints

- Nouns: Software, Operating System, Laptop, Desktop, Memory, Sound Card, Video Card, Keyboard, Mouse, Monitor
- Verbs: Options, Sold with, Installed



1.25 LAB: University Database

Nouns:

- Faculty,
- Student,
- Grad_student,
- Department,
- Section,
- Current_section,
- Course,
- Grant,
- College

Verbs

- Faculty and Grad_student can teach section
- Faculty advises Grad_student

- Faculty members are a thesis committee of a grad_student
- Faculty and Grad_student are supported by grant
- Faculty is a PI of grant
- student has a relationship with a current section
- student has a relationship with a section
- student has a relationship with a department
- Faculty has a relationship with a department
- College has a relationship with a department

1.26 University Database Example

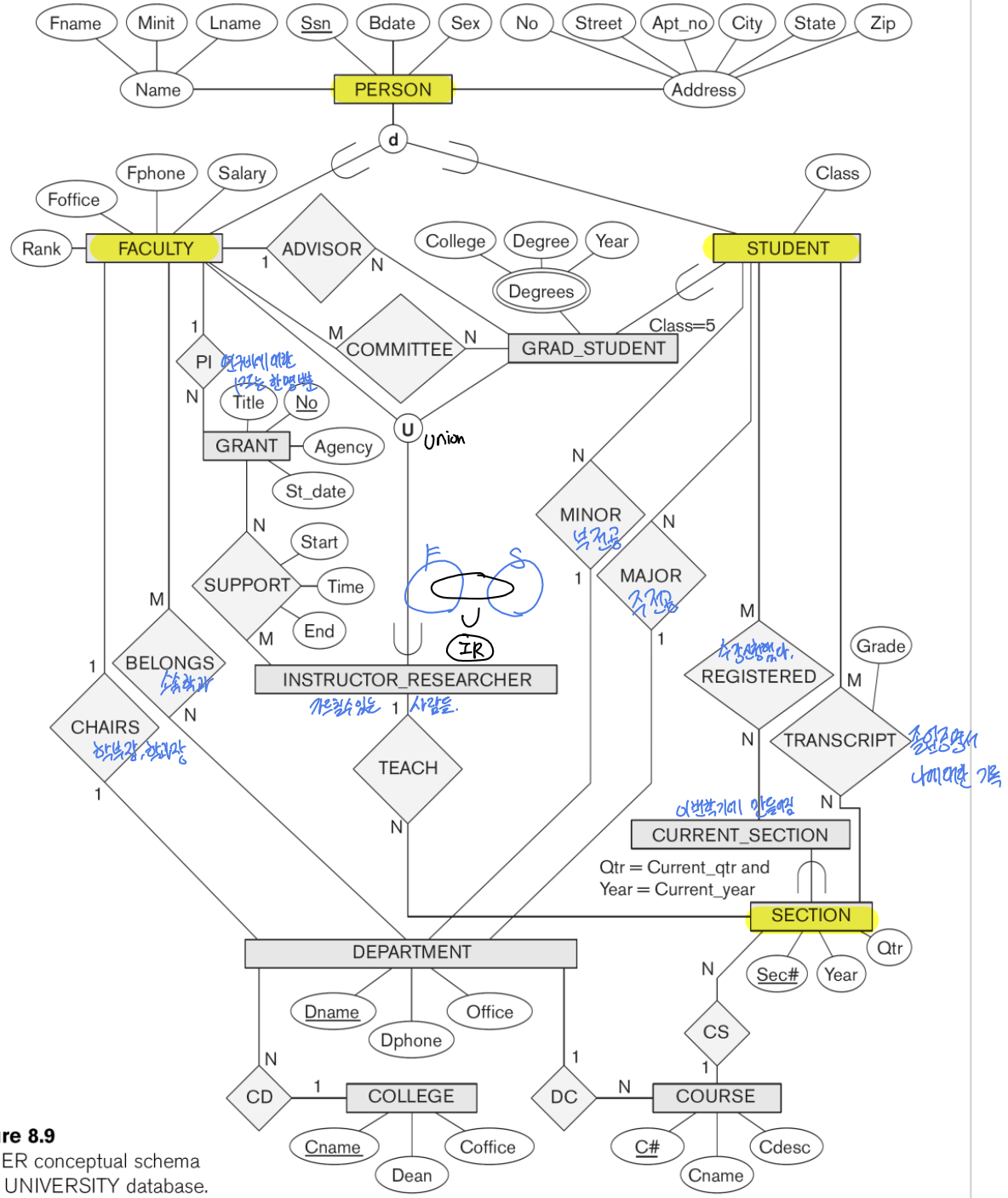


Figure 8.9
An EER conceptual schema for a UNIVERSITY database.