The Enhanced Entity-Relationship (EER) Model

406.426 Design & Analysis of Database Systems

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outline

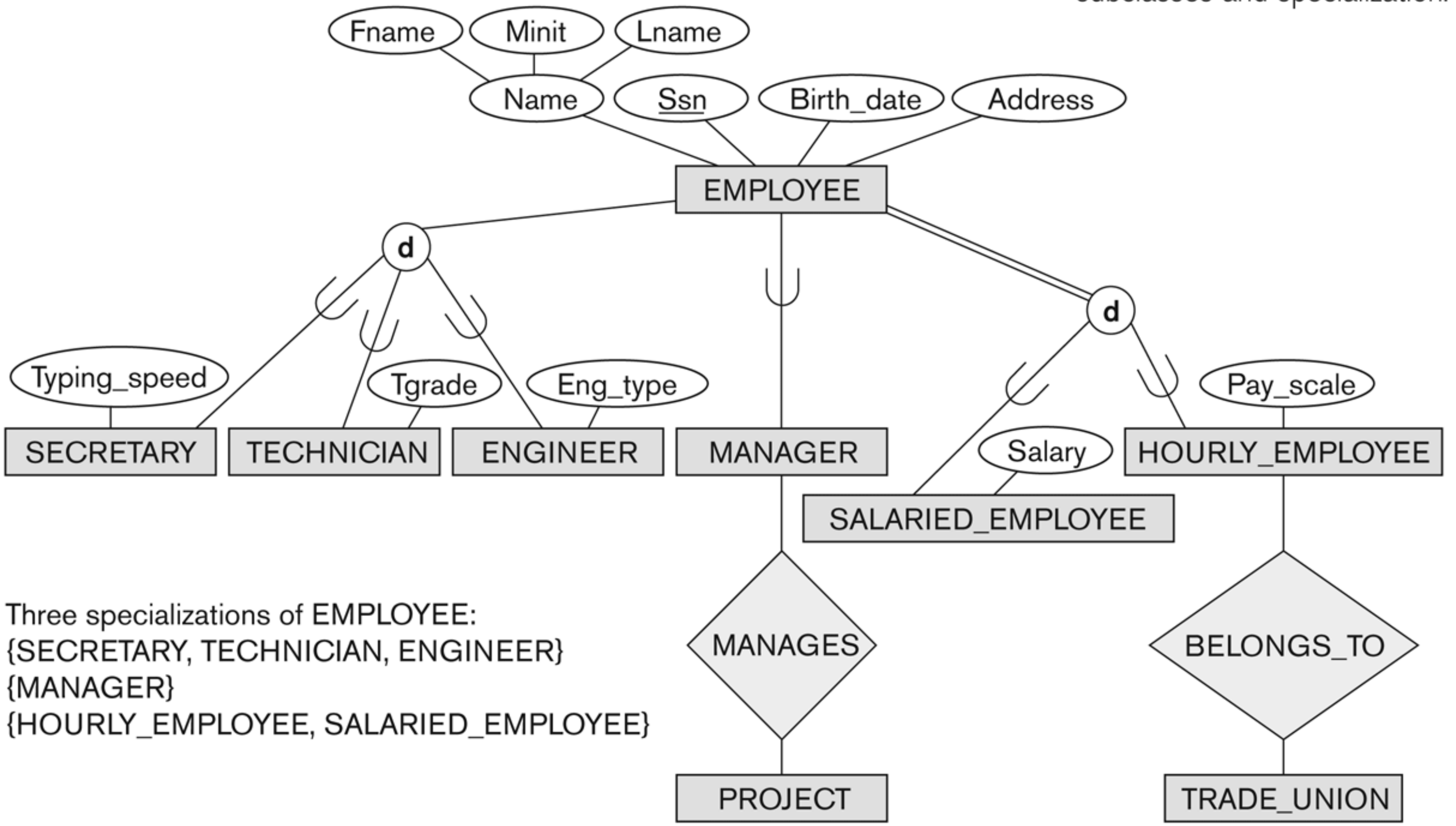
- EER model concepts
  - includes all modeling concepts of basic ER
  - additional concepts:
    - subclasses/superclasses
    - specialization/generalization
    - categories (UNION types)
    - attribute and relationship inheritance
  - these are fundamental to conceptual modeling
- the additional EER concepts are used to model applications more completely and more accurately
  - EER includes some object-oriented concepts, such as inheritance

subclasses, superclasses, and inheritance

- EER (Enhanced ER)
  - ER + subclass, superclass, specialization, generalization, category, attribute and relationship inheritance
- superclass / subclass relationship
  - example: SECRETARY, ENGINEER, MANAGER, … -> a **subset** of the entities that belong to the EMPLOYEE entity set
  - an entity cannot exist in the DB merely by being a member of a subclass -> it **must also be a member of the superclass**
  - it is not necessary that every entity in a superclass be a member of some subclass
  - an entity that is a member of a subclass **inherits all the attributes** of the entity as a member of the superclass
  - the subclass entity also **inherits all the relationships** in which the superclass participates

EER diagram for subclasses and specialization

Figure 4.1
EER diagram notation to represent subclasses and specialization.

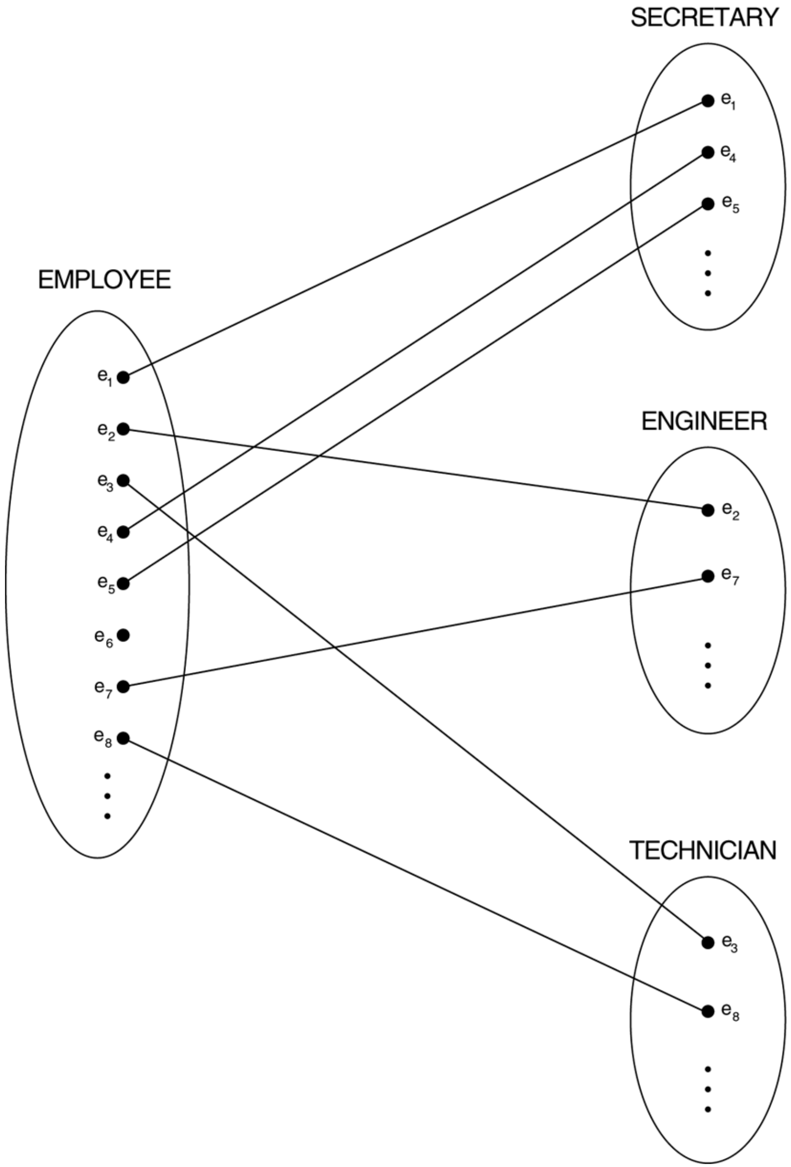


Three specializations of EMPLOYEE:
{SECRETARY, TECHNICIAN, ENGINEER}
{MANAGER}
{HOURLY_EMPLOYEE, SALARIED_EMPLOYEE}

specialization

- 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
- specific attributes
  - attributes that apply **only to entities of a particular subclass**
- specific relationship types
  - e.g., BELONGS_TO relationship type
- allows us to
  - define a set of **subclasses** of an entity type
  - establish **additional specific attributes** with each subclass
  - establish **additional specific relationship types** between each subclass and other entity types or other subclasses

instances of a specialization



generalization

- generalization: the process of **generalizing** several entity types into a **single superclass** of which the original entity types are special subclasses
  - e.g., CAR, TRUCK -> VEHICLE
  - the inverse of the specialization process

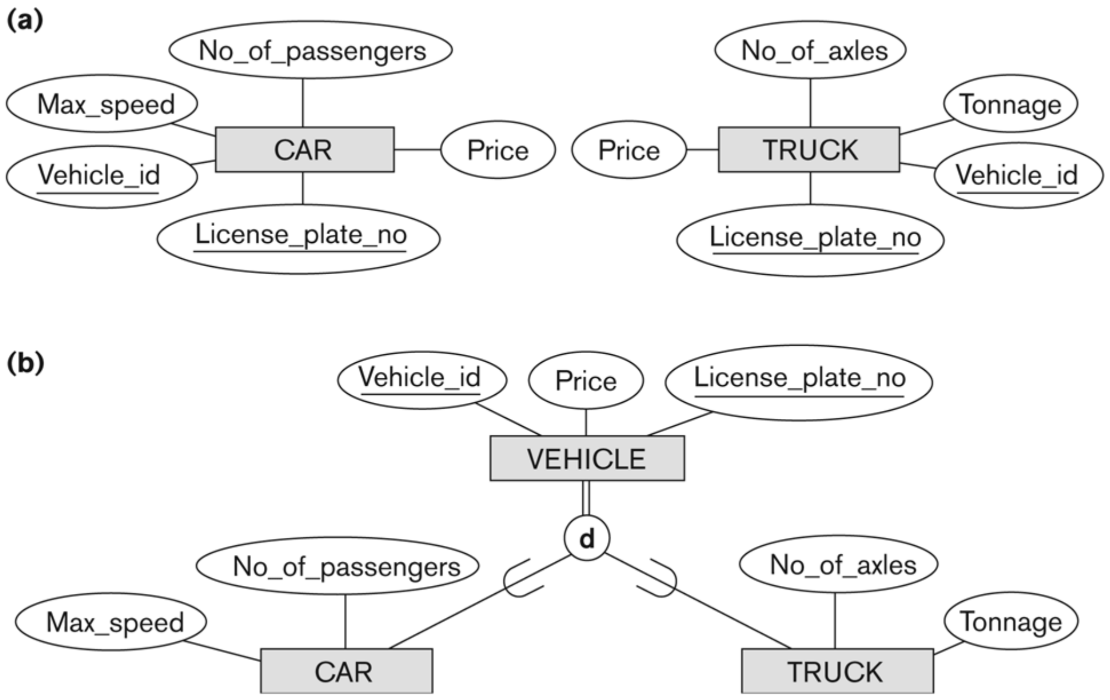
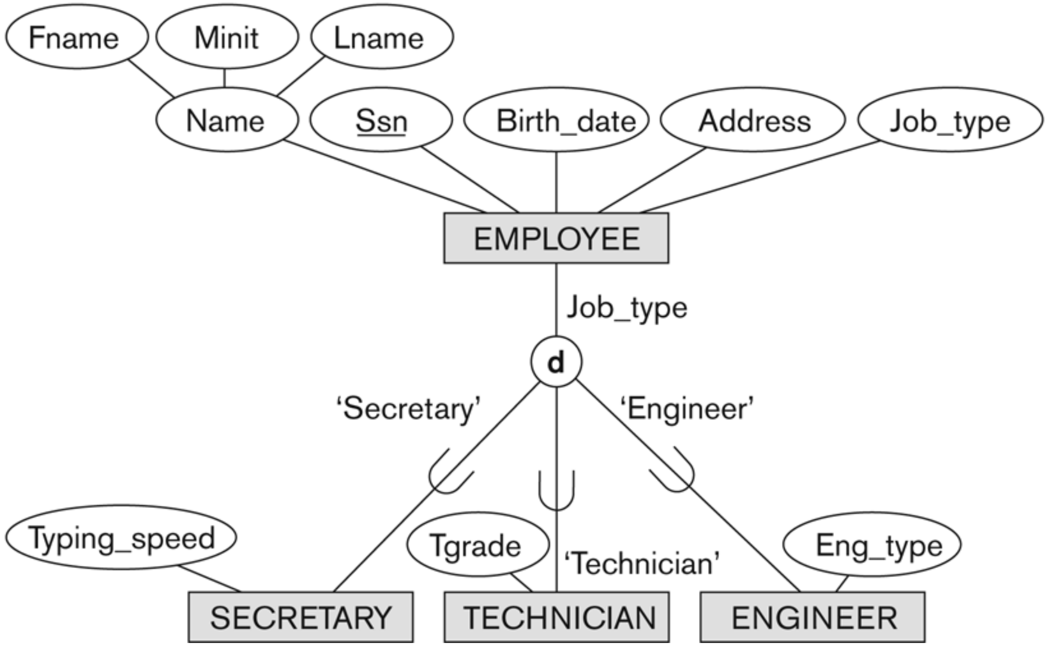


Figure 4.3
Generalization. (a) Two entity types, CAR and TRUCK.
(b) Generalizing CAR and TRUCK into the superclass VEHICLE.

constraints on specialization and generalization

- in general, we may have several specializations defined on the same entity type
- **predicate-defined** subclasses: the entities that become members of each subclass by placing a **condition** on the value of some attribute of the superclass
  - e.g., (JobType = ‘Secretary’) on SECRETARY
- if all subclasses in a specialization have their membership condition on the same attribute of the superclass, the specialization is called an **attribute-defined specialization**
- user-defined: specified individually **for each entity** by the user

Figure 4.4
EER diagram notation for an attribute-defined specialization on Job_type.



constraints on the specialization

- **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
  - a specialization that is **attribute defined** implies the **disjointness** constraint if the attribute used to define the membership predicate is **single-valued**
  - notations: d, o

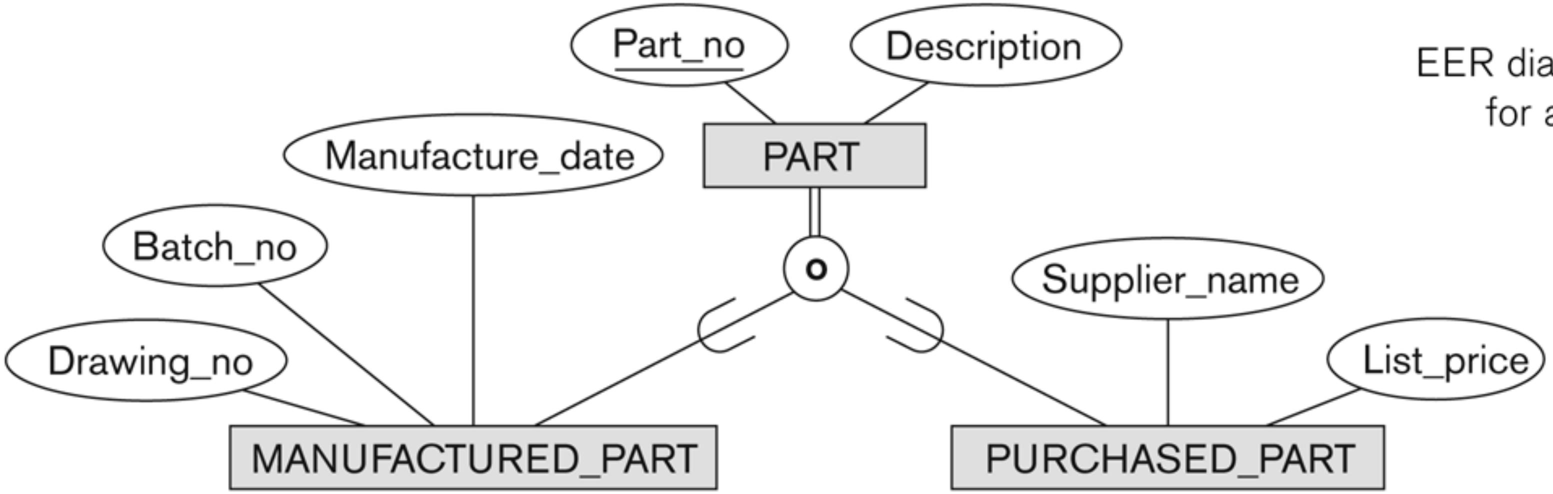


Figure 4.5
EER diagram notation for an overlapping (nondisjoint) specialization.

constraints on the specialization

- **completeness** constraint
  - **total specialization**: every entity in the superclass must be a member of at least one subclass in the specialization
  - **partial specialization**: **allows an entity not to belong to any of the subclasses**
- disjointness and completeness constraints are **independent**
  - i.e., disjoint, total / disjoint, partial / overlapping, total / overlapping, partial
- in general, a superclass that was identified through the **generalization** process usually is **total**
- some rules on the insertion and deletion
  - **deleting** an entity from a superclass implies that it is automatically deleted from all the subclasses to which it belongs
  - **inserting** an entity in a superclass implies that the entity is mandatorily inserted in all predicate-defined (or attribute-defined) subclasses for which the entity satisfies the defining predicate
  - **inserting** an entity in a superclass of a total specialization implies that the entity is mandatorily inserted **at least one** of the subclasses of the specialization

specialization hierarchies vs. lattices

- specialization **hierarchies**
  - every subclass must participate as a subclass in only **one** class/subclass relationship
- specialization **lattices**
  - a subclass can be a subclass in more than one class/subclass relationship

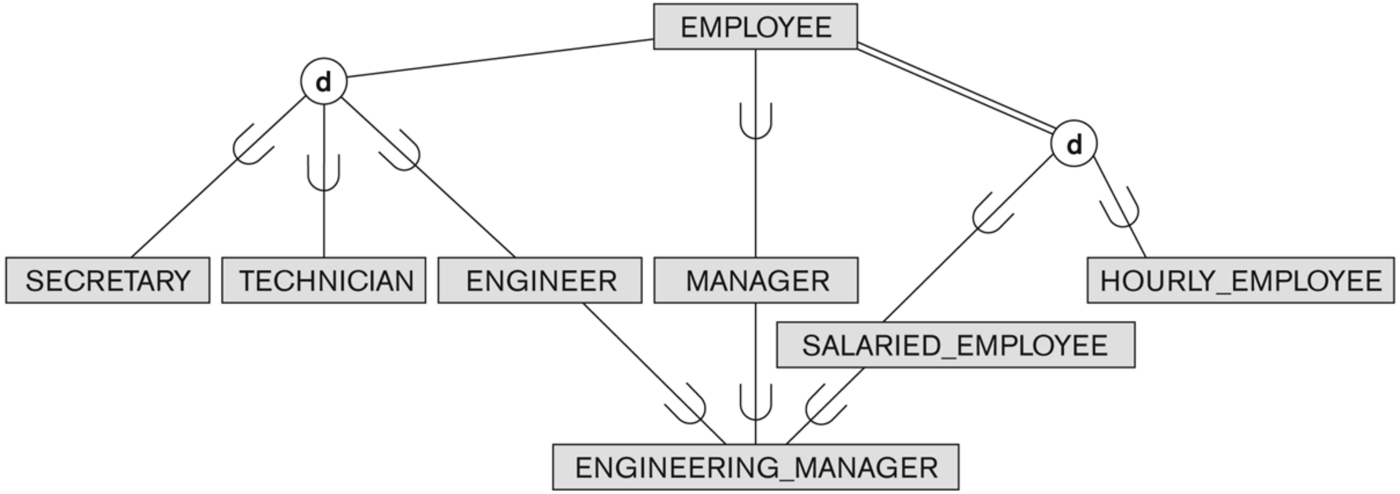


Figure 4.6
A specialization lattice with shared subclass ENGINEERING_MANAGER.

characteristics of specialization

- a subclass inherits the attributes not only of its direct superclass but also of all its **predecessor** superclasses all the way to the root of the hierarchy or lattice
- an entity may exist in several leaf nodes of the hierarchy
  - e.g., GRADUATE_STUDENT and RESEARCH_ASSISTANT
- a subclass with more than one superclass is called a **shared subclass**
- some models do not allow multiple inheritance
  - need to create additional subclasses to cover all possible combinations of classes that may have some entity belong to all these classes simultaneously
  - e.g., {EMPLOYEE, ALUMNUS, STUDENT} -> E, A, S, E_A, E_S, A_S, E_A_S

example

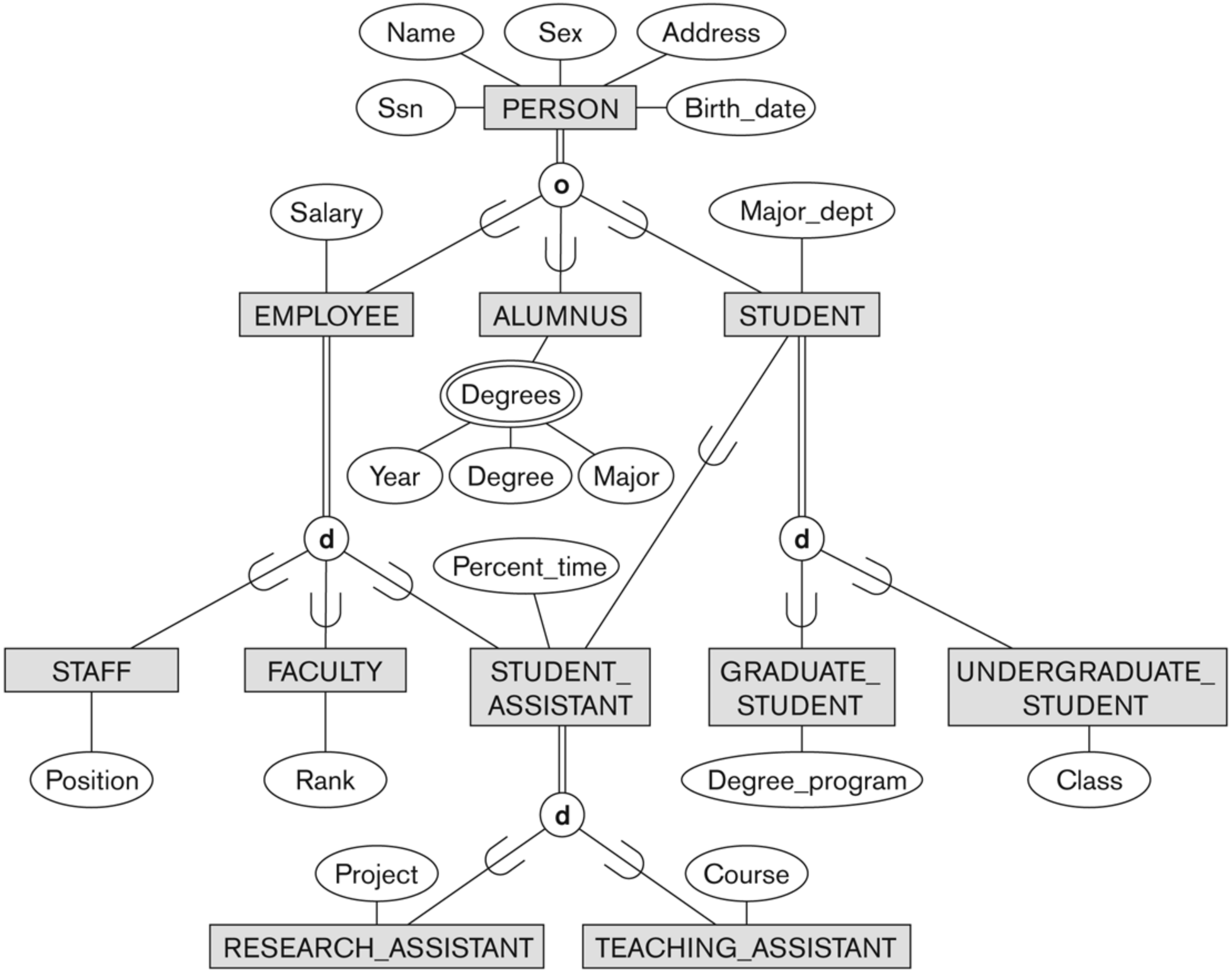


Figure 4.7
A specialization lattice with multiple inheritance for a UNIVERSITY database.

categories

- modeling a single superclass / subclass relationship with **more than one superclass**
- the subclass will represent a collection of objects that is a **subset** of the **UNION** of distinct entity types: called a **category**
  - example: OWNER

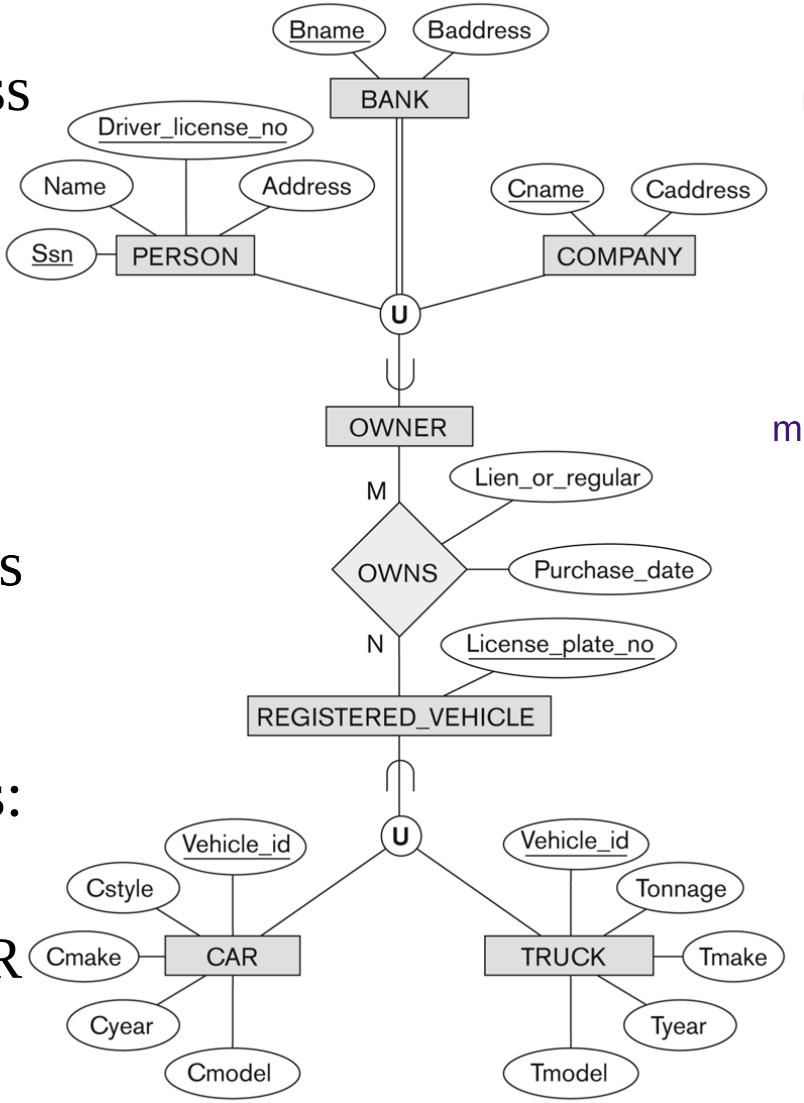


Figure 4.8
Two categories (union types): OWNER and REGISTERED_VEHICLE.

mushroom

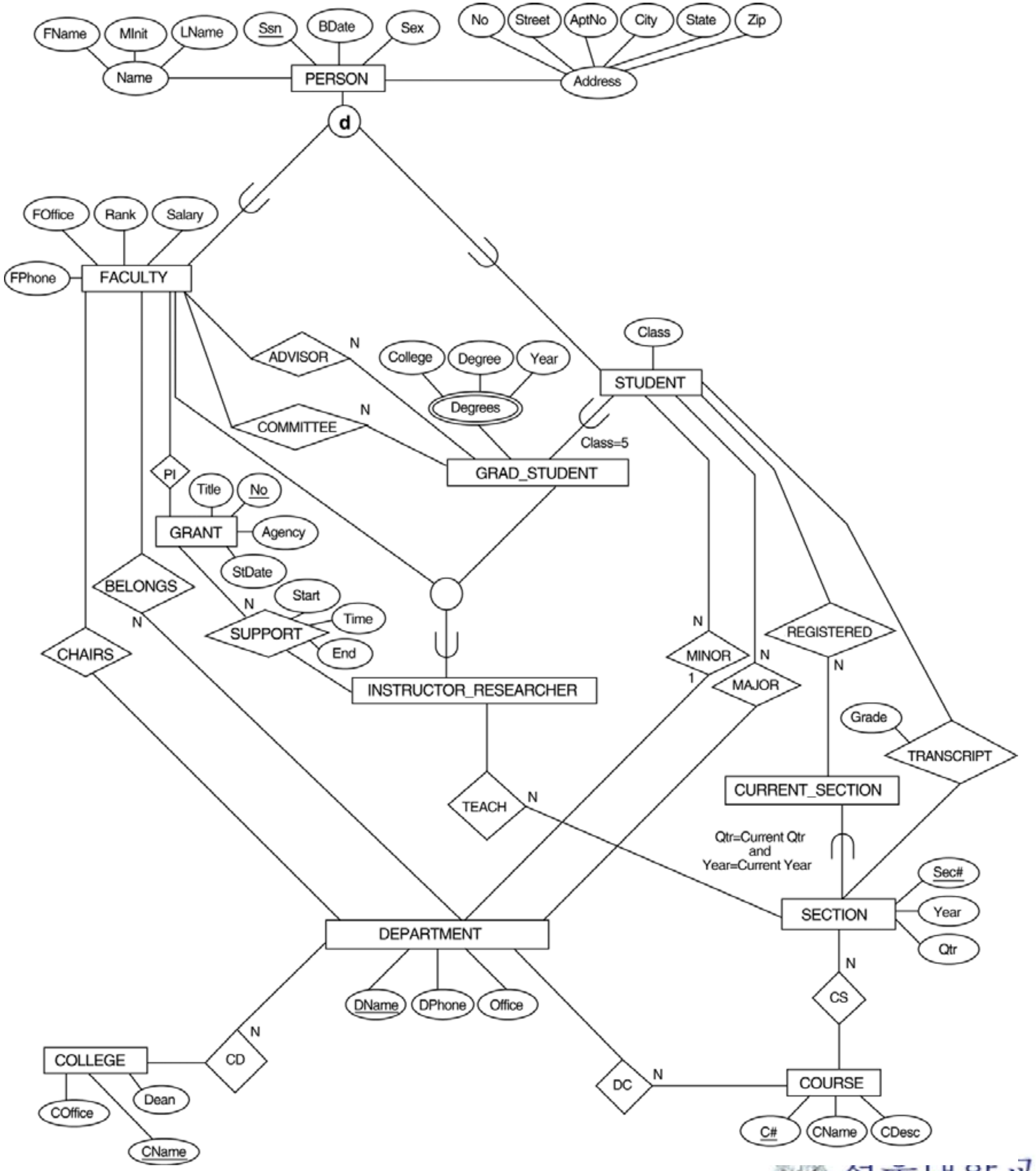
person

skull

category (cont.)

- comparison with the shared subclass
  - shared subclass
    - a subset of the **intersection** of the three superclasses
    - inherits all the attributes of its superclasses
  - category
    - a subset of the **union** of its superclasses
    - **inherits** the attributes **selectively** depending on the superclass to which the entity belongs
- category can be total or partial
  - a total category holds the union of all **entities** in its superclass
  - a partial category holds a subset of the union
  - if a category is total, it may be represented alternatively as a **total specialization (or a total generalization)**

summing up



FName
MInit
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AptNo
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FPhone
FACULTY
Class
ADVISOR
N
College
Degree
Year
STUDENT
Degrees
COMMITTEE
N
Class=5
GRAD_STUDENT
PI
Title
No
GRANT
Agency
StDate
BELONGS
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Start
N
Time
SUPPORT
End
CHAIRS
INSTRUCTOR_RESEARCHER
N
MINOR
1
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MAJOR
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Grade
TRANSCRIPT
TEACH
N
CURRENT_SECTION
Qtr=Current Qtr and Year=Current Year
Sec#
Year
Qtr
SECTION
DEPARTMENT
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DName
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Office
CS
N
CD
COLLEGE
DC
N
COURSE
Dean
COffice
CName
C#
CName
CDesc

formal definitions for the EER model

- class: a set or collection of entities
  - e.g., entity types, subclasses, superclasses, categories
- subclass S is a class whose entities must always be a subset of the entities in another class, called the superclass C of the superclass/subclass (or IS-A) relationship (denoted by C/S)
  - i.e., $S \subseteq C$
- a specialization $Z = \{S_1, S_2, \ldots, S_n\}$ is a set of subclasses that have the same superclass G (denoted by G/S_i)
  - G is called a generalized entity type
  - Z is said to be total if $\cup S_i = G$; partial, o.w.
  - Z is said to be disjoint if $S_i \cap S_j = \phi$ for $i \neq j$; overlapping, o.w.

formal definitions for the EER model (cont.)

- a subclass *S* of *C* is said to be **predicate-defined** if a predicate *p* on the attributes of *C* is used to specify which entities in *C* are members of *S*
  - $S = C[p]$
- a specialization *Z* (or generalization *G*) is said to be **attribute-defined** if a predicate ($A = c_i$), where *A* is an attribute of *G* and c_i is a constant value from the domain of *A*, is used to specify membership in each subclass S_i in *Z*
- a category *T* is a class that is a subset of the union of *n* defining superclasses, D_1, D_2, …, D_n, $n > 1$
  - $T \subseteq (D_1 \cup D_2 \ldots \cup D_n)$
- a predicate p_i on the attributes of D_i can be used to specify the members of each D_i that are members of *T*
  - $T = (D_1[p_1] \cup D_2[p_2] \ldots \cup D_n[p_n]\ )$

specialization/generalization in UML

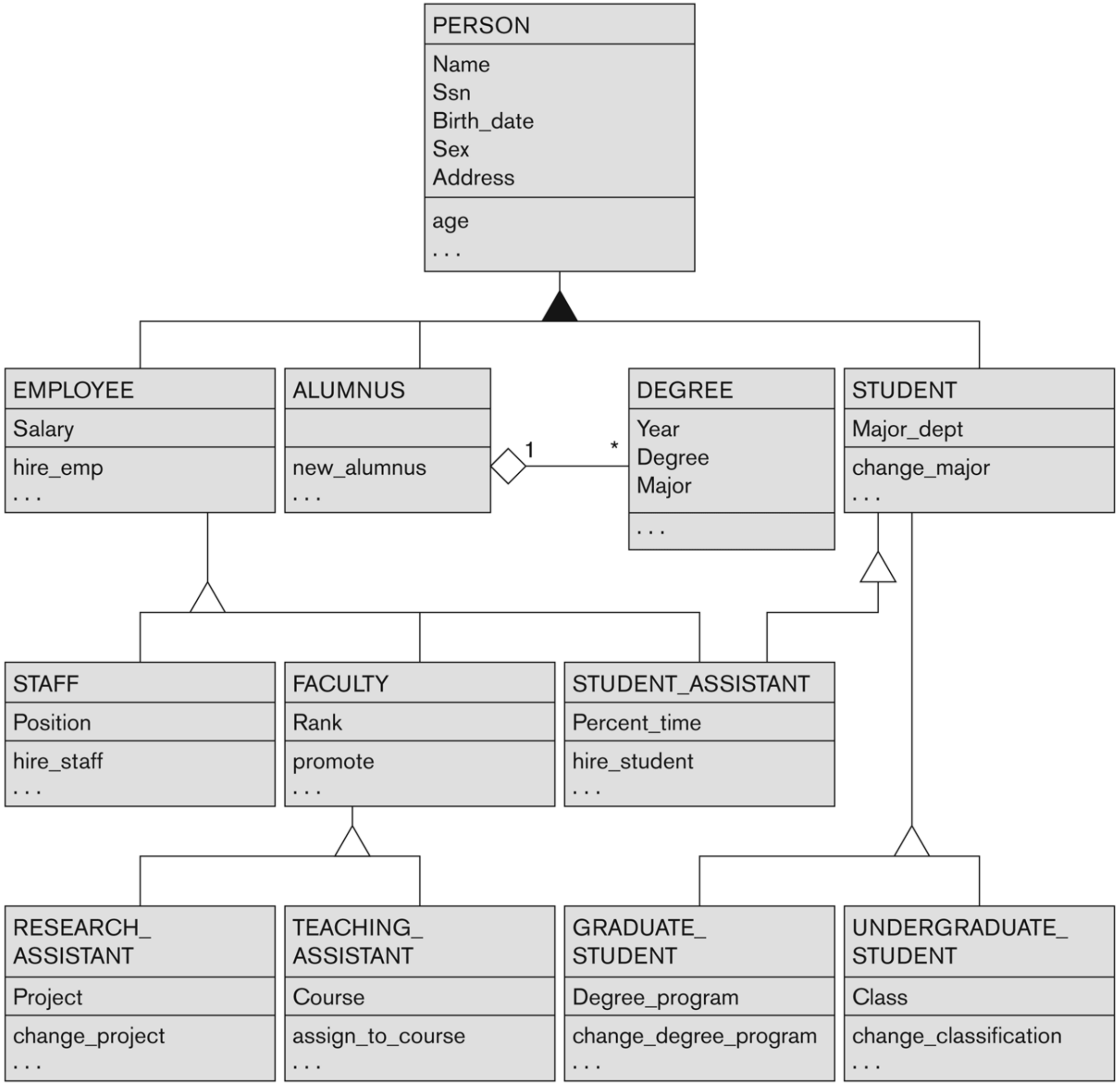
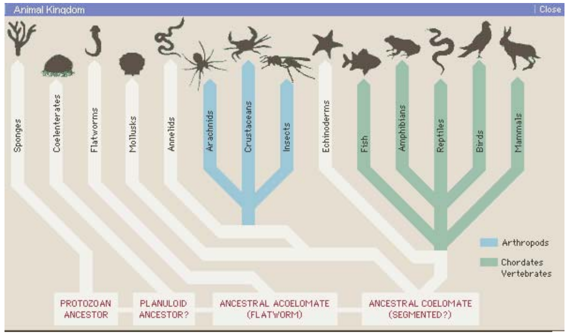
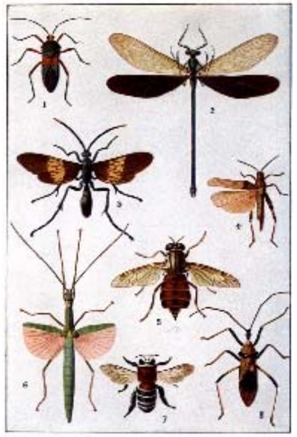


Figure 4.10
A UML class diagram corresponding to the EER diagram in Figure 4.7, illustrating UML notation for specialization/generalization.

abstraction concepts

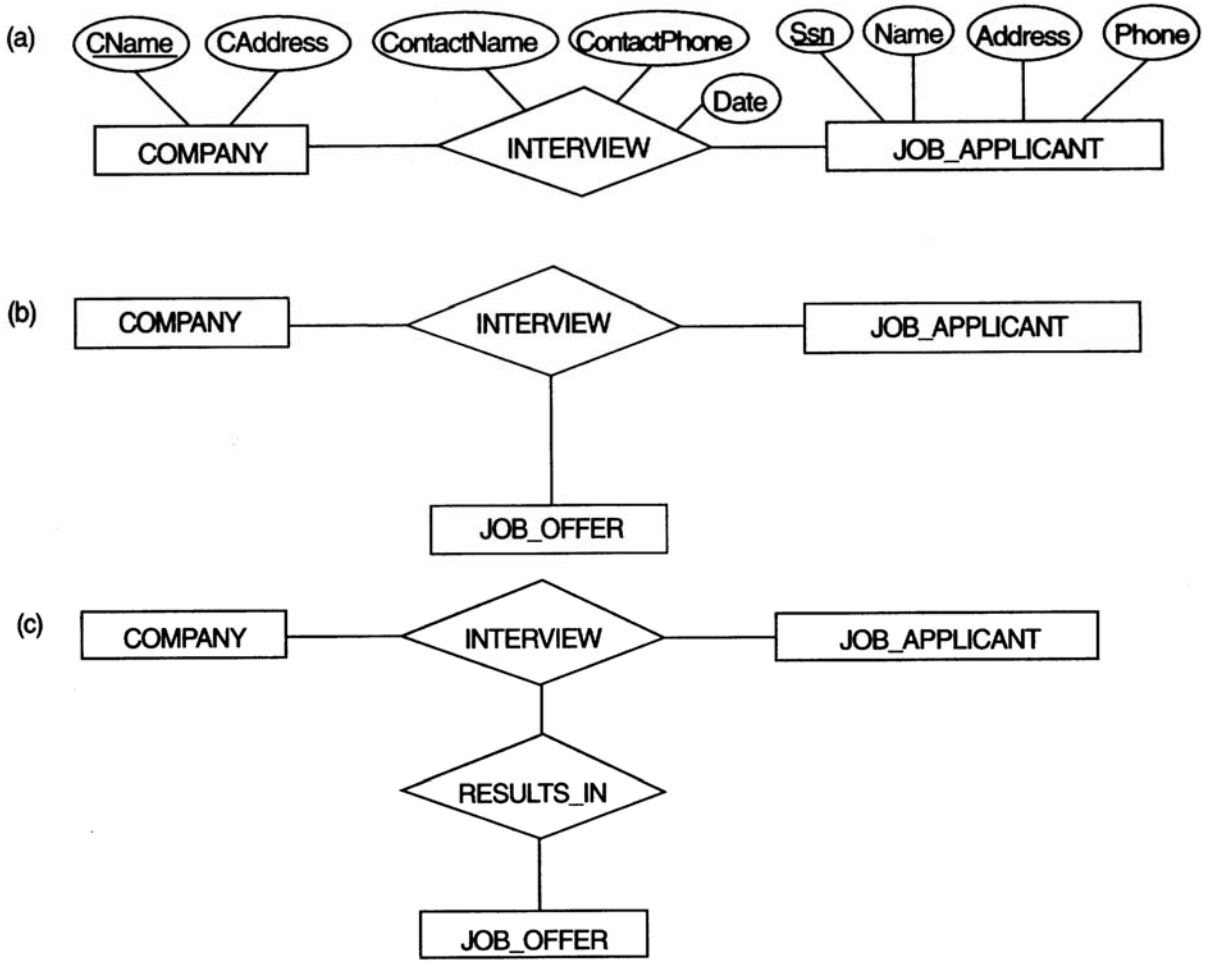
- classification and instantiation
  - classification: systematically assigning similar objects to object classes
  - instantiation: generation of distinct objects of a class (IS-AN-INSTANCE-OF relationship)
- identification
  - abstraction process whereby classes and objects are made uniquely identifiable by means of some **identifier**
- specialization and generalization
  - specialization: the process of classifying a class of objects into more specialized subclasses
  - generalization: generalizing several classes into a higher level abstract class that includes the objects in all these classes (IS-A relationship)
- aggregation and association
  - **aggregation**: building composite objects from their component objects (IS-A-PART-OF)
  - **association**: association of objects from several independent classes (IS-ASSOCIATED-WITH)





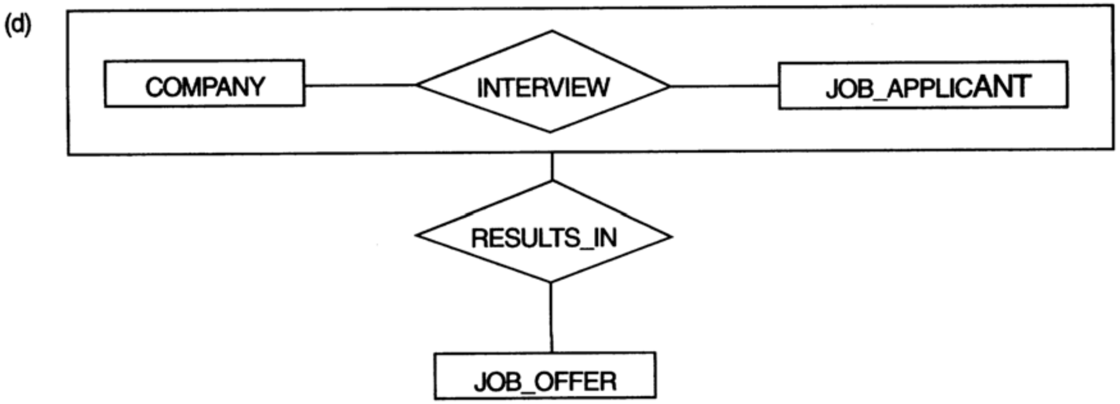
concept of aggregation and association

- suppose that some interviews result in job offers, whereas others do not

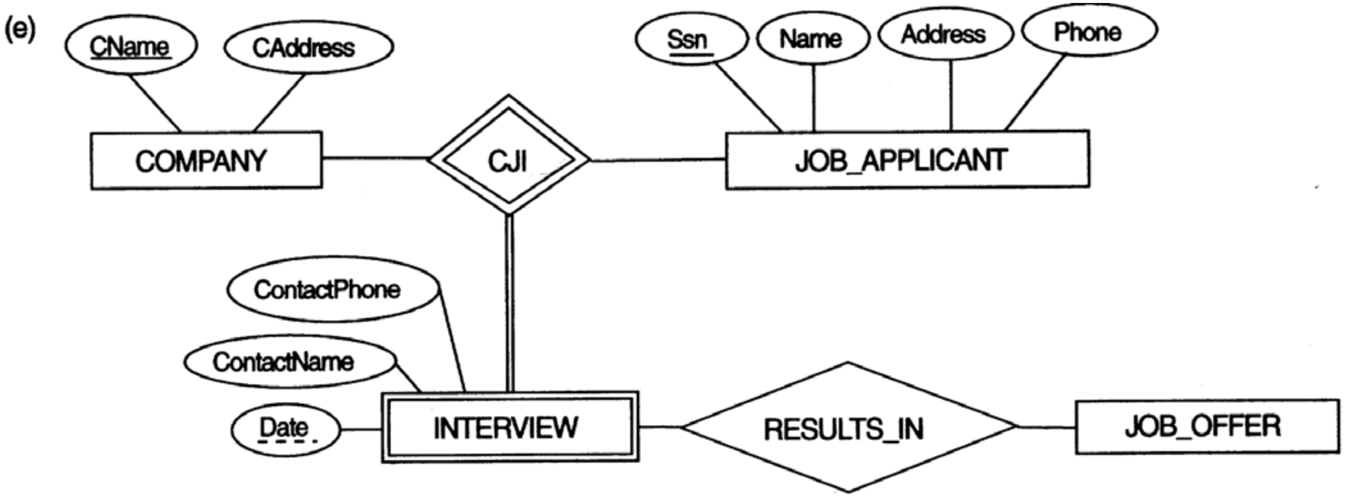


concept of aggregation and association (cont.)

- composite object (not allowed in ER)



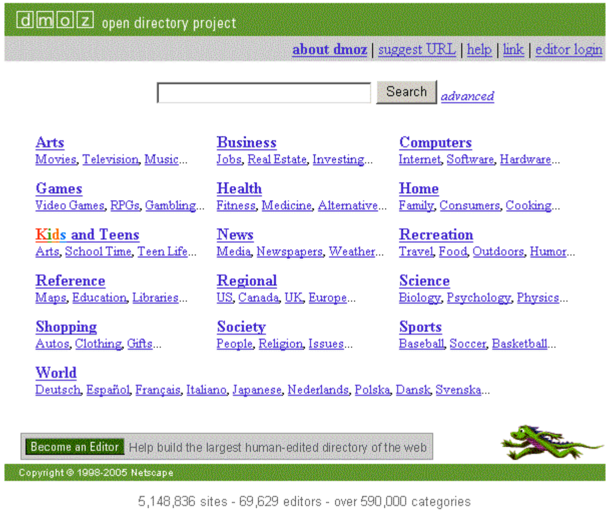
- creation of a new **weak entity type** INTERVIEW



semantic web and ontology

- semantic web
  - to allow **information exchange among computers** on the web
  - attempts to create knowledge representation models that are quite general in order to allow meaningful information exchange and **search among machines**
- ontology
  - a specification of a **conceptualization**
  - attempts to describe the **structures** and **relationships** that are possible in reality through some common vocabulary, and so it can be considered as a way to **describe the knowledge** of a certain community about reality
  - possible techniques: thesaurus, dictionary, taxonomy, database schema, logical theory, …

W3C® World Wide Web consortium



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