BITS, PILANI – K. K. BIRLA GOA CAMPUS

Database Systems and Applications

(IS F243)

by

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Chapter 3: Enhanced Entity-Relationship Model

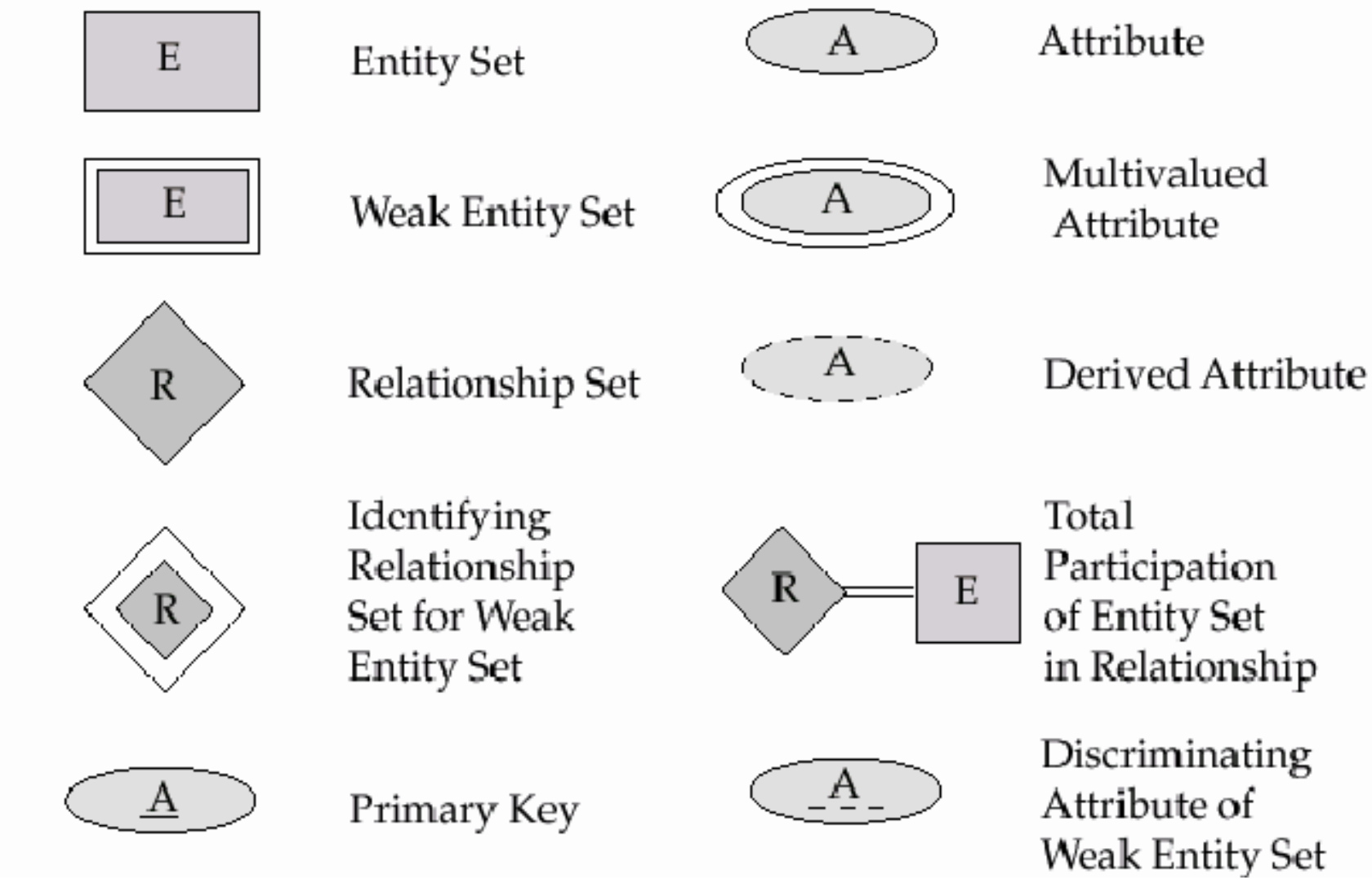
PROBLEM with ER notation

THE ENTITY RELATIONSHIP MODEL IN ITS ORIGINAL FORM DID NOT SUPPORT THE SPECIALIZATION/ GENERALIZATION.

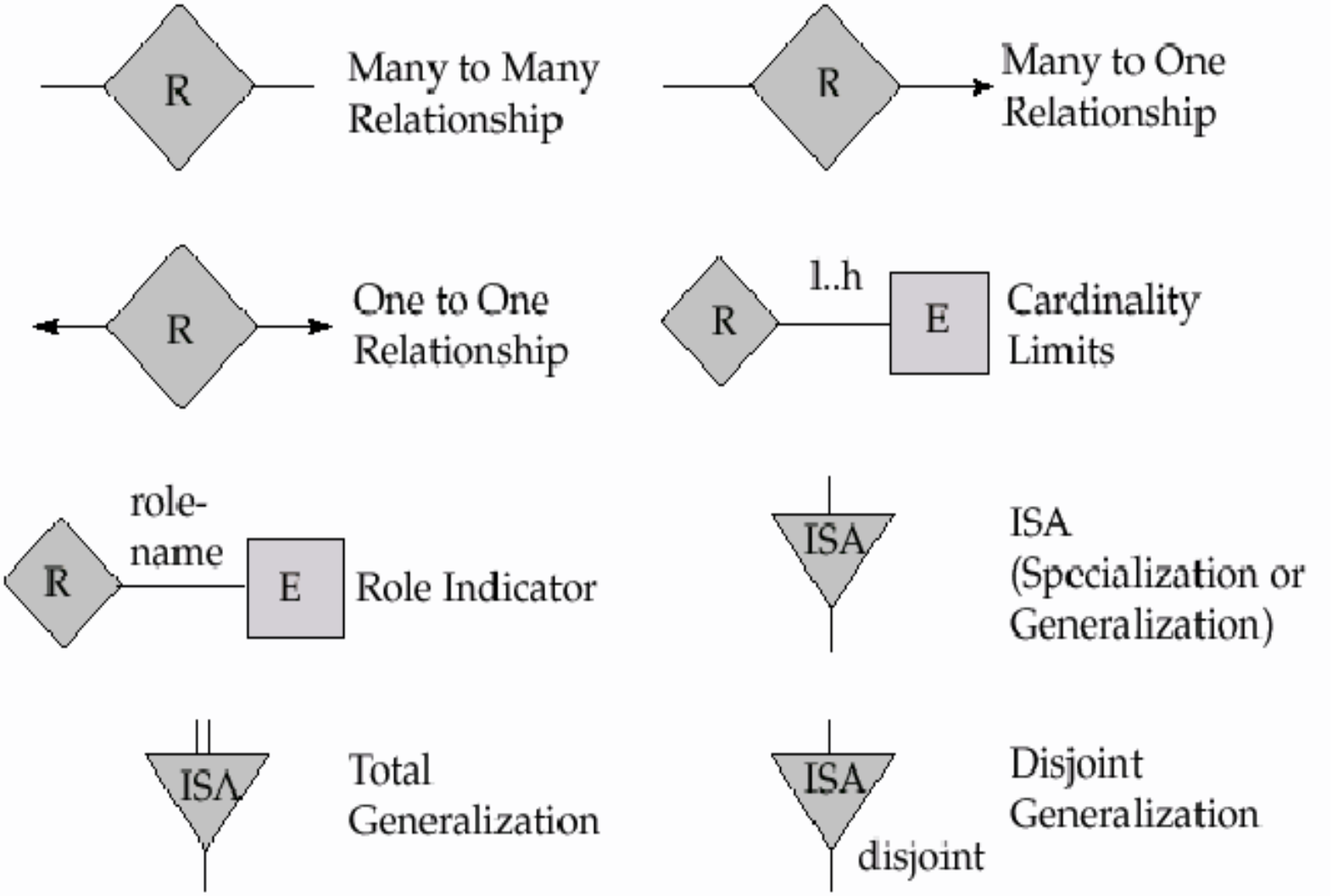
Extended Entity-Relationship (EER) Model

- Incorporates Set-subset relationships
- Incorporates Specialization/Generalization Hierarchies

Symbols used in ER diagram



Symbols used in ER diagram



Enhanced Entity-Relationship Model

Consider following relations

Stuid	name	addr	dob	degree type	second degree	dept	Ps stn	Ps durn

Empno	name	addr	dob	doj	post	Typing speed	Tech grade	Engg type

Enhanced-ER (EER) Model Concepts

- Includes all modeling concepts of basic ER
- Additional concepts: subclasses/superclasses, specialization/generalization, categories, attribute inheritance
- The resulting model is called the enhanced-ER or Extended ER (E2R or EER) model
- It is used to model applications more completely and accurately if needed
- It includes some object-oriented concepts, such as inheritance

Subclasses and Superclasses (1)

- An entity type may have additional meaningful **sub groupings** of its entities
- Example: EMPLOYEE may be further grouped into SECRETARY, ENGINEER, MANAGER, TECHNICIAN, SALARIED_EMPLOYEE, HOURLY_EMPLOYEE,…
  - Each of these groupings 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.**
- Example: EMPLOYEE/SECRETARY, EMPLOYEE/TECHNICIAN

Subclasses and Superclasses (2)

- 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
- Example: A salaried employee who is also an engineer belongs to the two subclasses ENGINEER and SALARIED_EMPLOYEE
  - It is not necessary that every entity in a superclass be a member of some subclass

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
- It also inherits all relationships

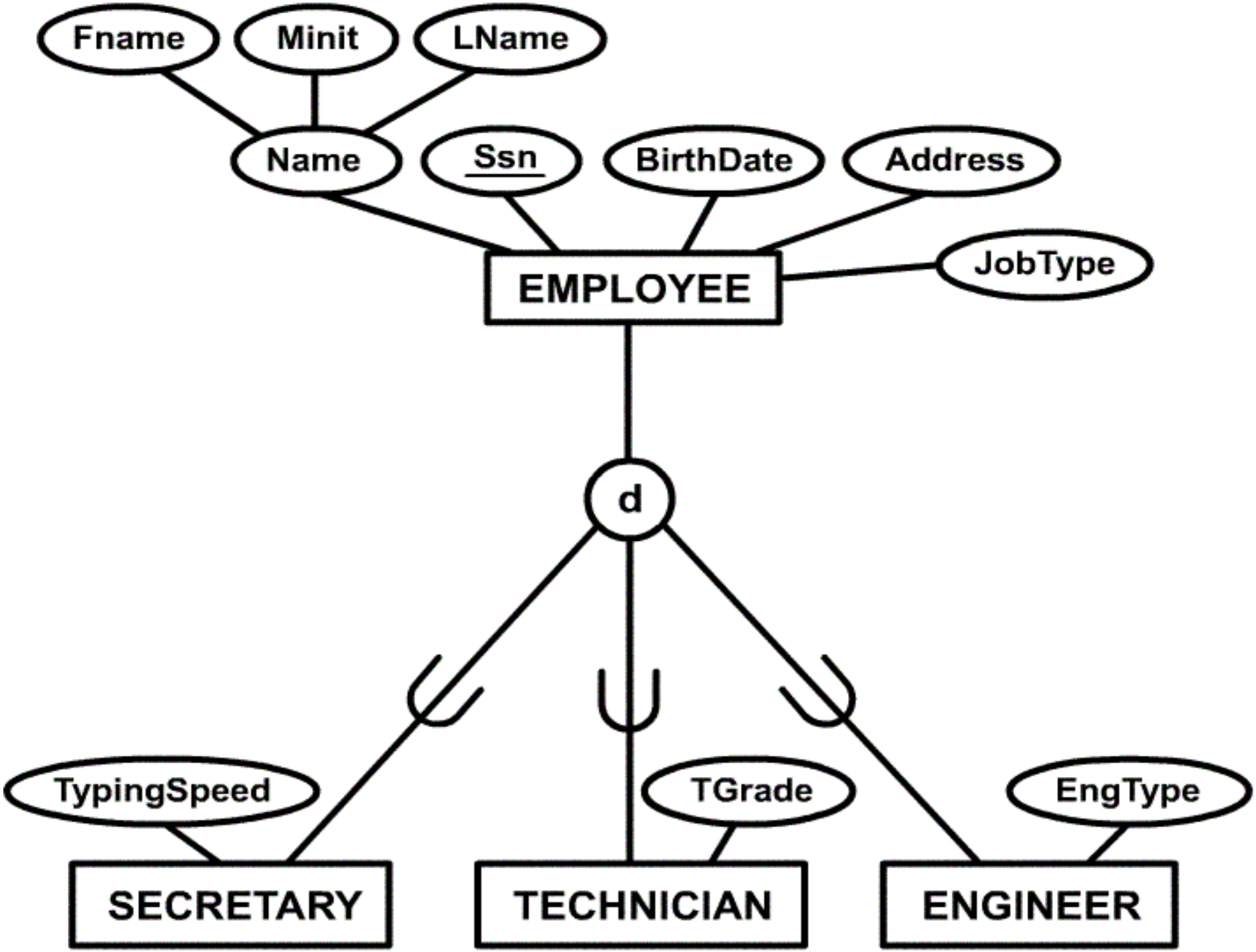
Specialization

- 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

Specialization

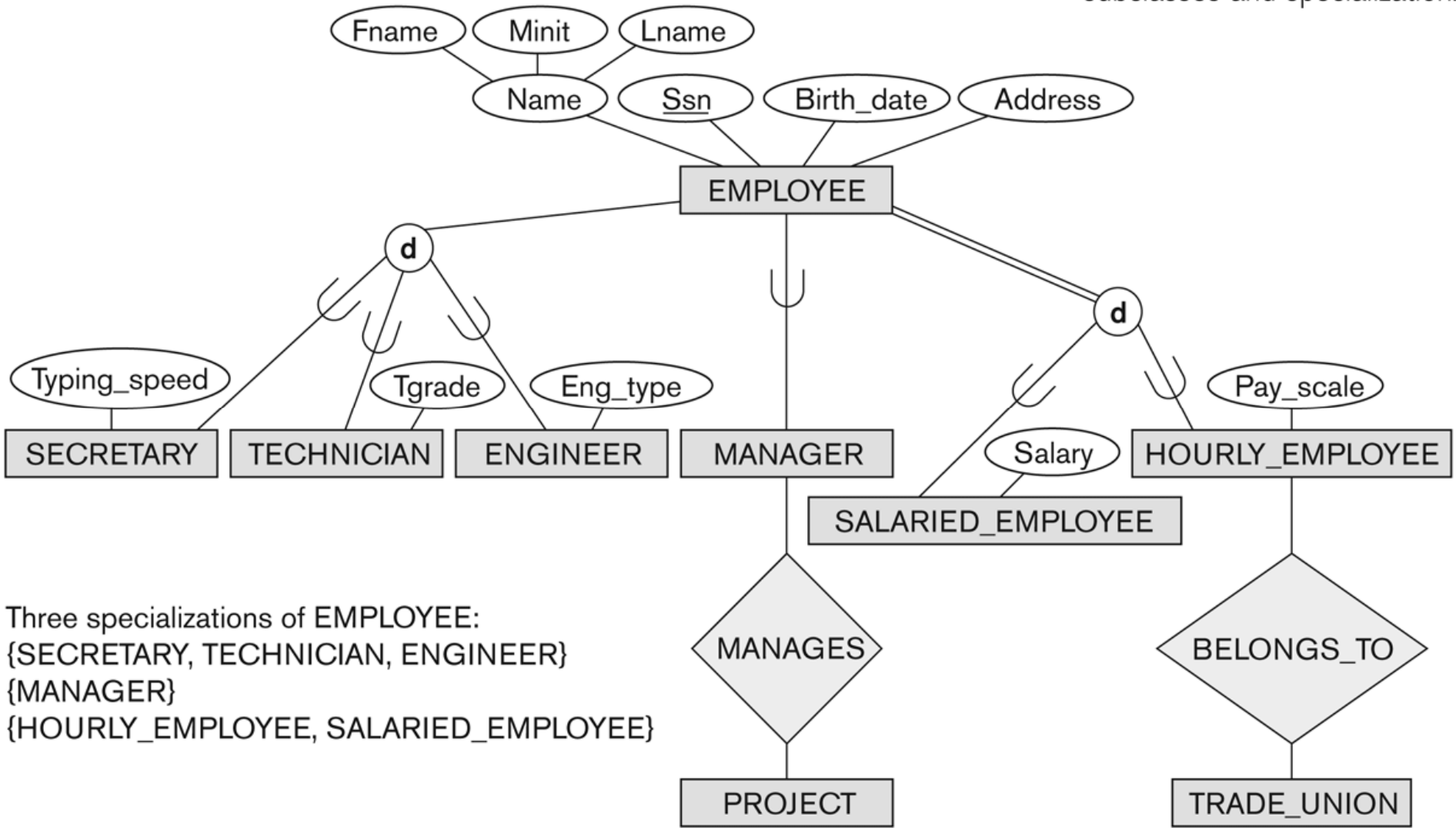
- Example: Another specialization of **EMPLOYEE** based in ***method of pay*** is {**SALARIED_EMPLOYEE, HOURLY_EMPLOYEE**}.
  - Superclass/subclass relationships and specialization can be diagrammatically represented in EER diagrams as inverted triangle.

  - Attributes of a subclass are called specific attributes. For example, TypingSpeed of SECRETARY
  - The subclass can participate in specific relationship types. For example, BELONGS_TO of HOURLY_EMPLOYEE


Fname
Minit
LName
Name
Ssn
BirthDate
Address
JobType
EMPLOYEE
d
TypingSpeed
TGrade
EngType
SECRETARY
TECHNICIAN
ENGINEER

SPECIALIZATION

Figure 4.1
EER diagram notation to represent subclasses and specialization.



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

Generalization

- 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

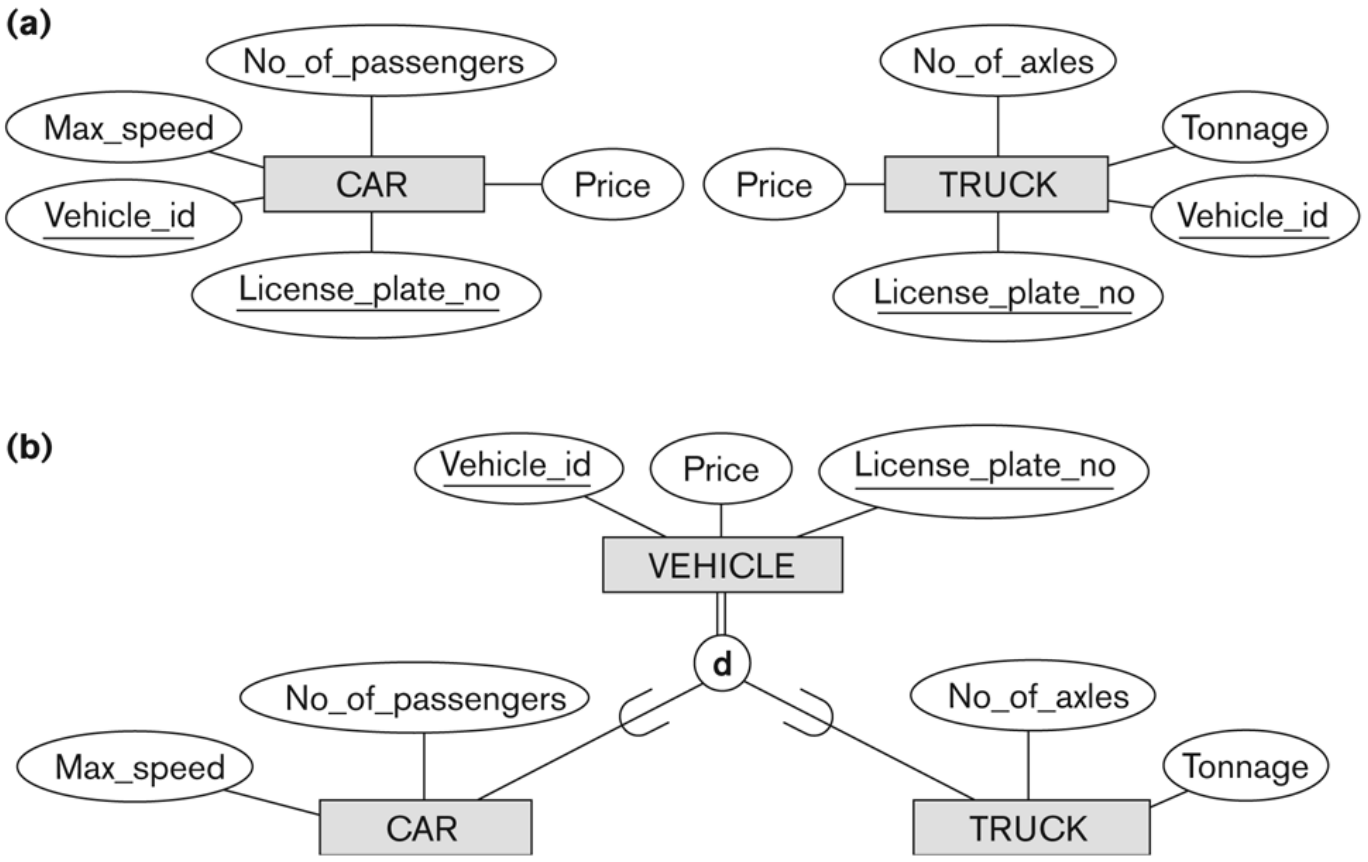


Figure 4.3
Generalization. (a) Two entity types, CAR and TRUCK.
(b) Generalizing CAR and TRUCK into the superclass VEHICLE.

Generalization and Specialization

- Diagrammatic notation 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 in these situations

Generalization and Specialization

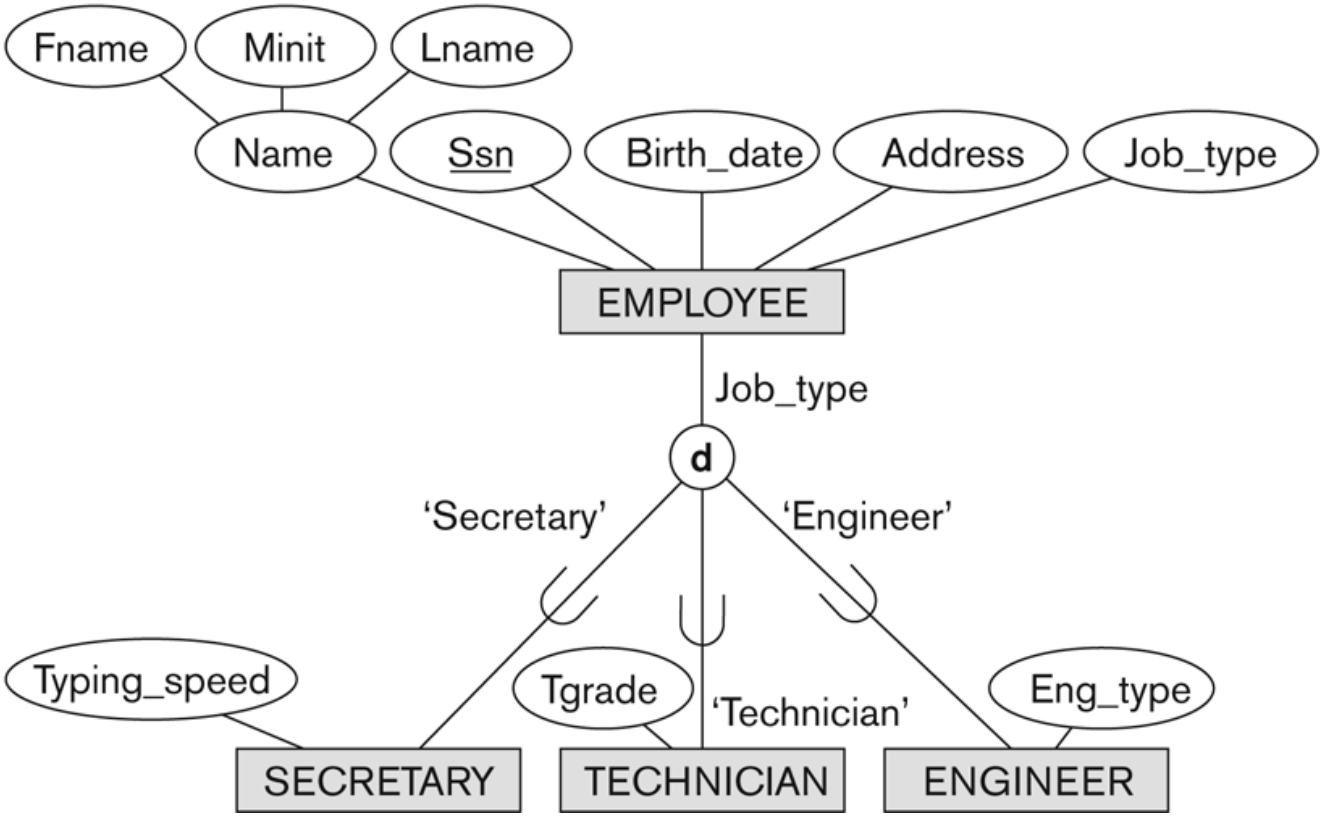
- Data Modeling with Specialization and Generalization
  - A superclass or subclass represents a set of entities shown in rectangles in EER diagrams (as are entity types)
  - Sometimes, all entity sets are simply called classes, whether they are entity types, superclasses, or subclasses

Constraints on Specialization and Generalization

- 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

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



Constraints on Specialization and Generalization

- 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

Constraints on Specialization and Generalization

- 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

Constraints on Specialization and Generalization

- Two other conditions apply to a specialization/generalization:
- **Disjointness Constraint**:
  - Specifies that the subclasses of the specialization must be disjointed (an entity can be a member of at most one of the subclasses of the specialization)
  - Specified by **d** in EER diagram
  - If not disjointed, overlap; 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

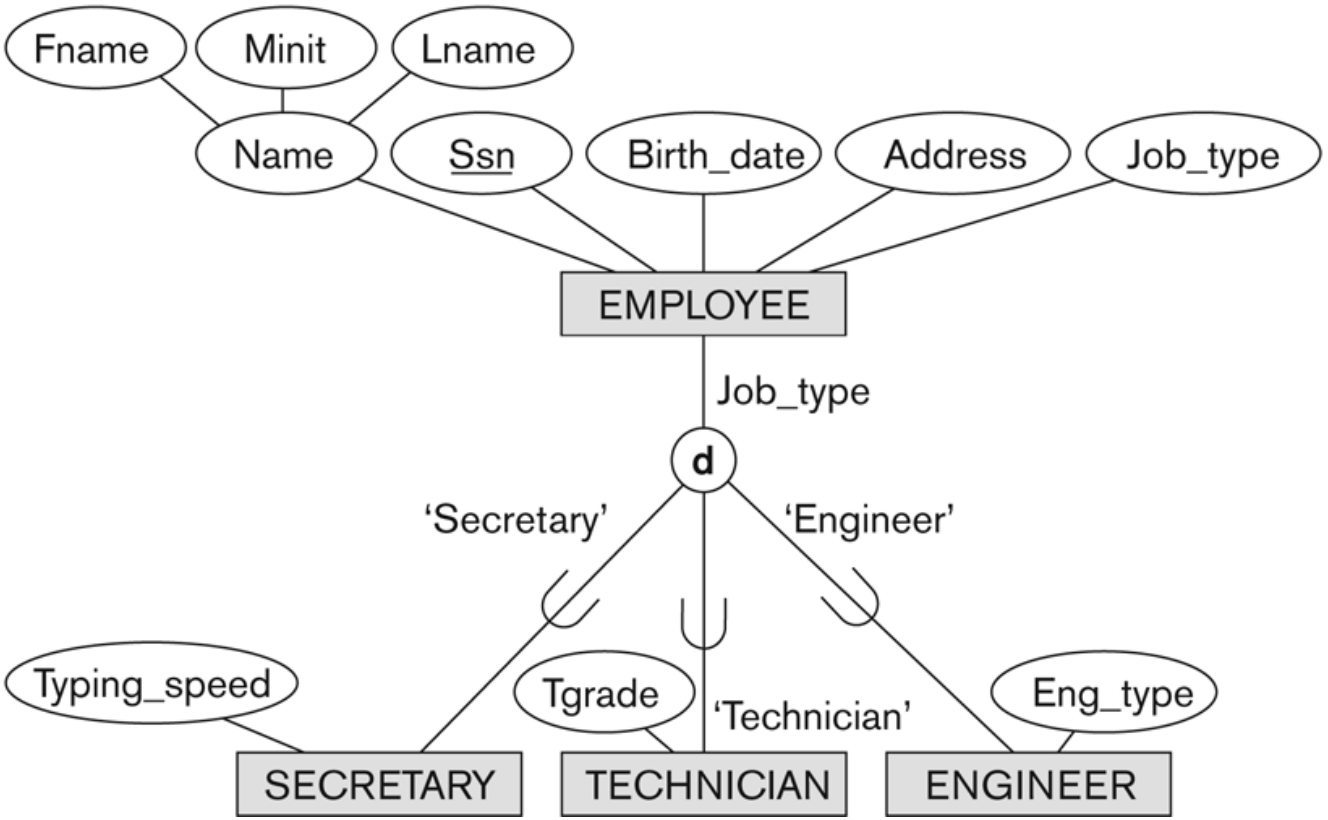
- **Completeness Constraint**:
  - Total specifies that every entity in the superclass must be a member of some subclass in the specialization/ generalization
  - Shown in EER diagrams by a **double line**
  - Partial allows an entity not to belong to any of the subclasses
  - Shown in EER diagrams by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

Constraints on Specialization and Generalization (3)

- 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

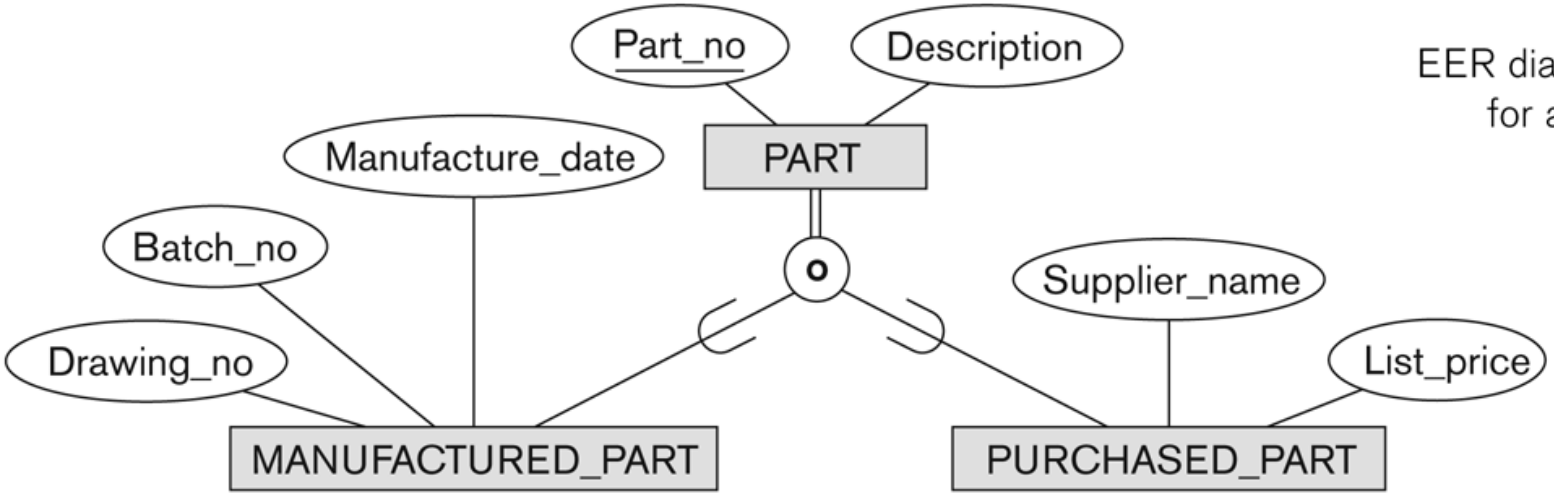


Figure 4.5
EER diagram notation for an overlapping (nondisjoint) specialization.

Specialization / Generalization Hierarchies, Lattices and Shared Subclasses

- A subclass may itself have further subclasses specified on it
- Forms a hierarchy or a lattice
- Hierarchy has a constraint that every subclass has only one superclass (called *single inheritance*)
- In a lattice, a subclass can be subclass of more than one superclass (called *multiple inheritance*)
- In a lattice or hierarchy, a subclass inherits attributes not only of its direct superclass, but also of all its predecessor superclasses

Specialization / Generalization Hierarchies, Lattices and Shared Subclasses

- A subclass with more than one superclass is called a shared subclass
- Can have specialization hierarchies or lattices, or generalization hierarchies or lattices
- In specialization, start with an entity type and then define subclasses of the entity type by successive specialization (**top down** conceptual refinement process)
- In generalization, start with many entity types and generalize those that have common properties (**bottom up** conceptual synthesis process)
- In practice, the combination of two processes is employed

Shared Subclass "Engineering_Manager"

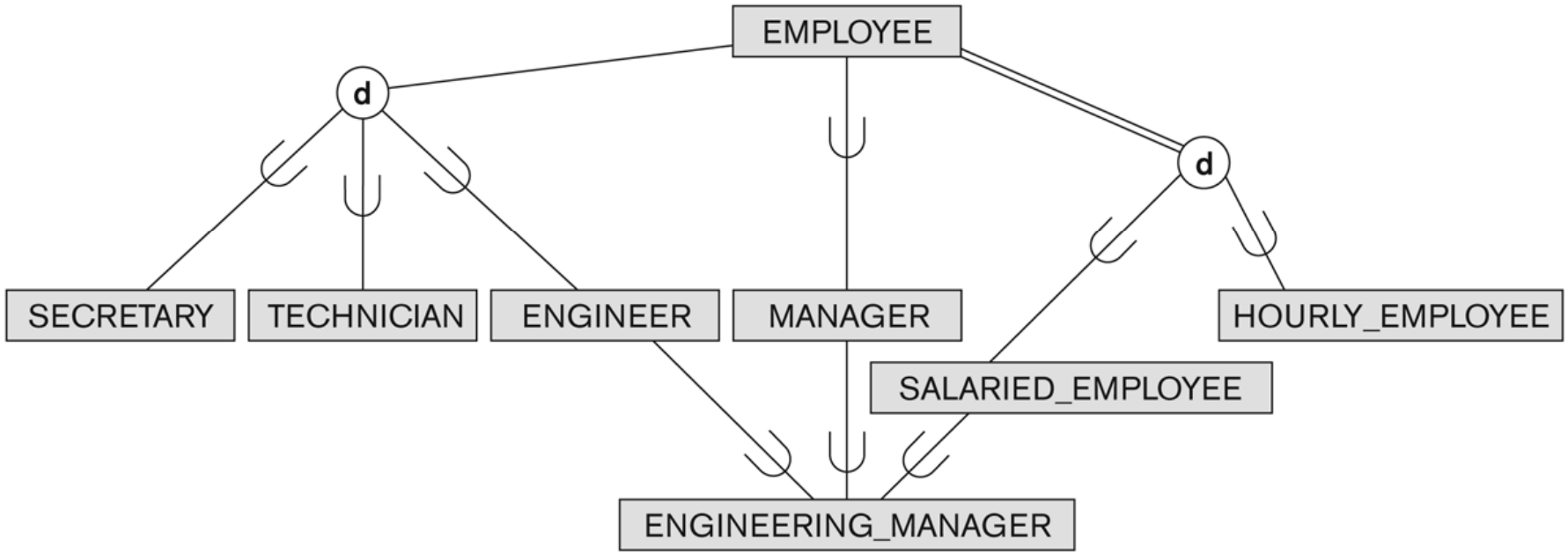
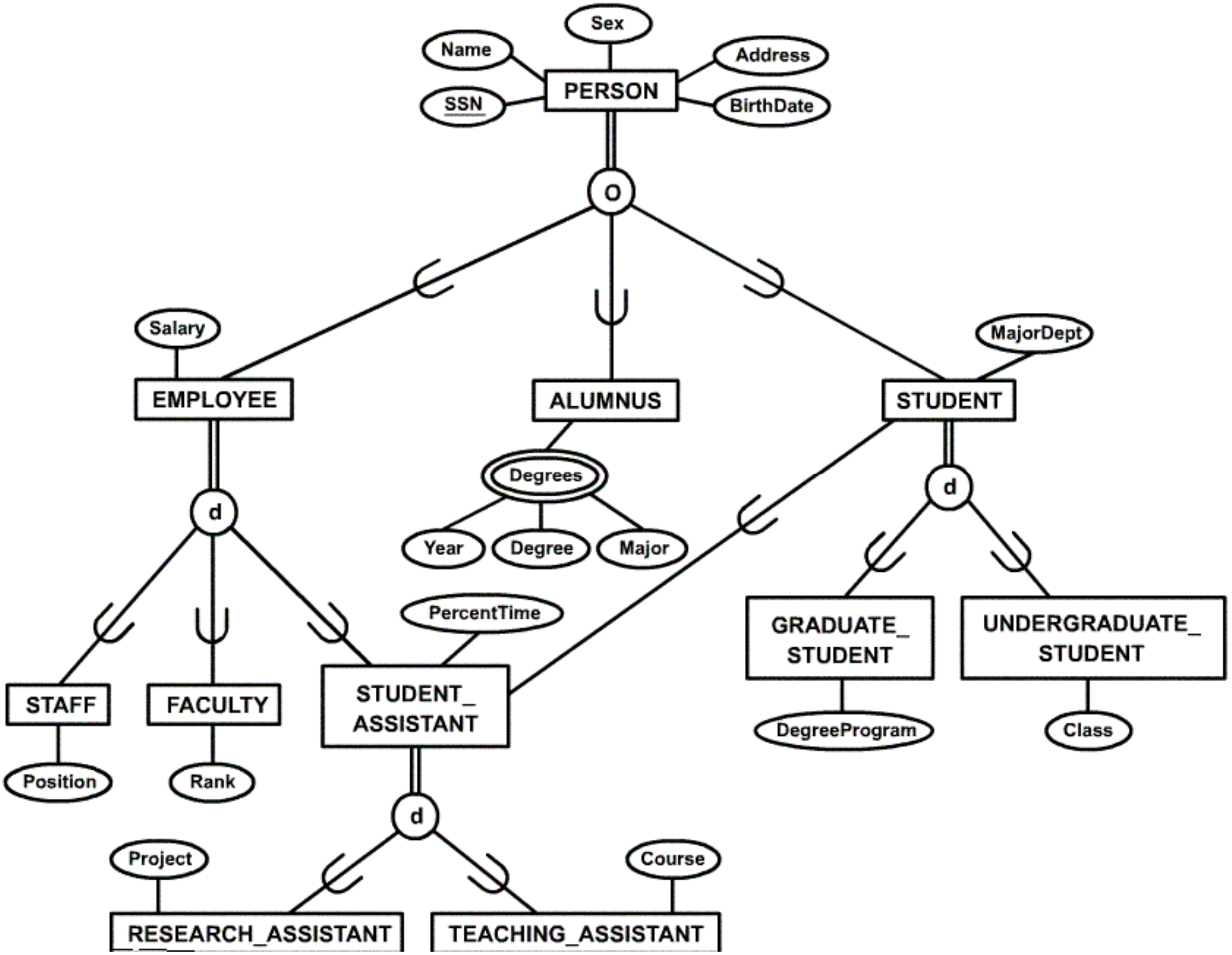


Figure 4.6
A specialization lattice with shared subclass ENGINEERING_MANAGER.

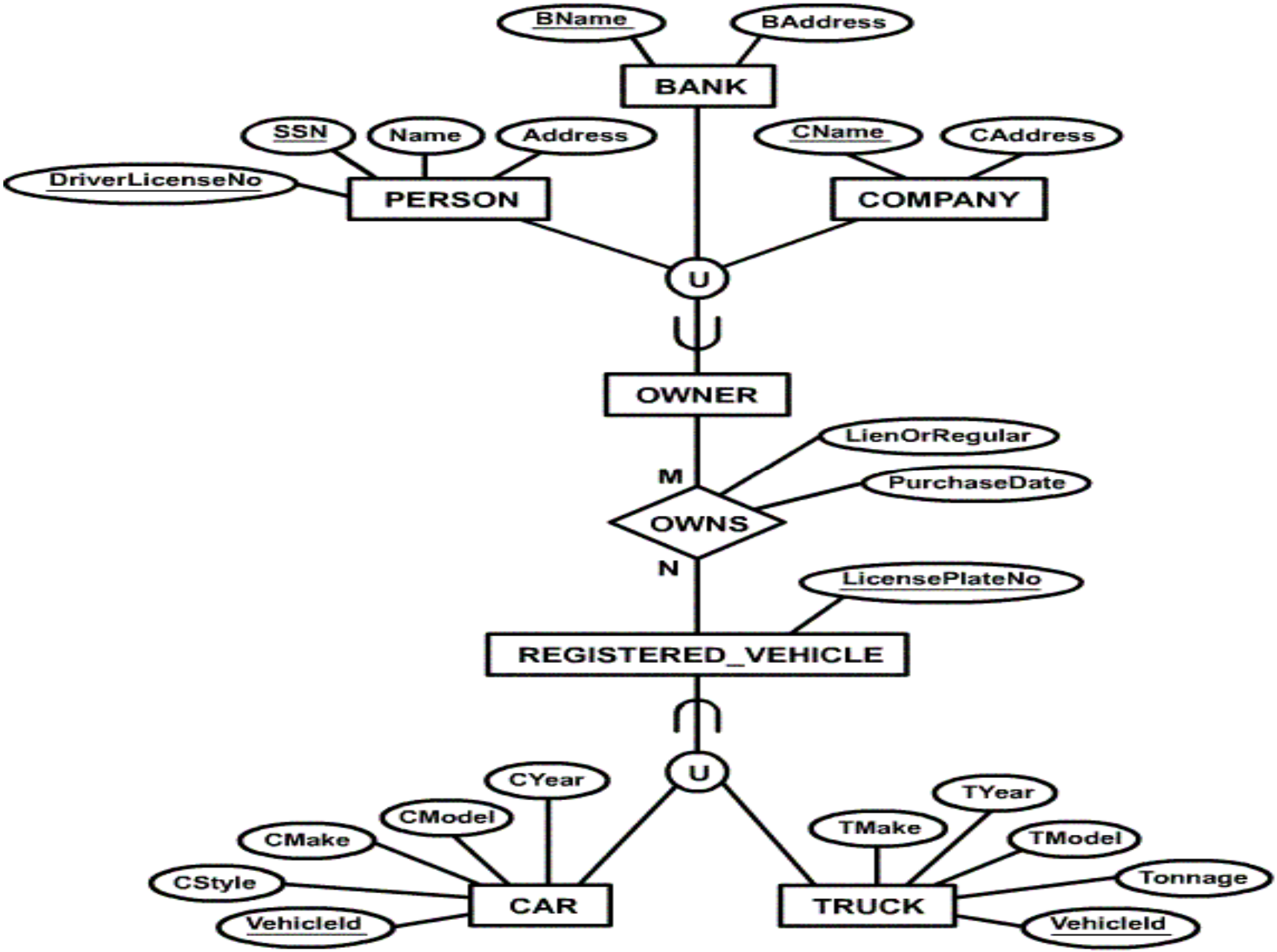

Sex
Name
Address
PERSON
SSN
BirthDate
O
Salary
MajorDept
EMPLOYEE
ALUMNUS
STUDENT
Degrees
d
d
Year
Degree
Major
PercentTime
GRADUATE_
STUDENT
UNDERGRADUATE_
STUDENT
STAFF
FACULTY
STUDENT_
ASSISTANT
DegreeProgram
Class
Position
Rank
d
Project
Course
RESEARCH_ASSISTANT
TEACHING_ASSISTANT

Categories (UNION TYPES)

- All of the superclass/subclass relationships we have seen thus far have a single superclass
- A shared subclass is subclass in more than one distinct superclass/subclass relationships, where each relationships has a single superclass (multiple inheritance)
- In some cases, need to model a single superclass/subclass relationship with more than one superclass
- Superclasses represent different entity types

Categories (UNION TYPES)

- Such a subclass is called a category or UNION TYPE
- Example: Database for vehicle registration, vehicle owner can be a person, a bank (holding a lien on a vehicle) or a company.
  - Category (subclass) OWNER is 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
- Note: The difference from shared subclass, which is subset of the intersection of its superclasses (shared subclass member must exist in all of its superclasses).


BName
BAddress
BANK
SSN
Name
Address
DriverLicenseNo
PERSON
CName
CAddress
COMPANY
U
OWNER
LienOrRegular
M
PurchaseDate
OWNS
N
LicensePlateNo
REGISTERED_VEHICLE
U
CYear
CModel
CMake
CStyle
VehicleId
CAR
TYear
TMake
TModel
Tonnage
TRUCK
VehicleId

ER AND EER MODELLING

- Design an Enhanced entity relationship diagram that models the following objects and relationships in the world of football (NFL): teams, players, games, managers and contracts.
- Each NFL team has a unique team name and a city it plays in.
- Each person being part of NFL world has a unique id and name.
- Additionally, for players their weight, height, position and birth dates are of importance.
- Players have a contract with at most one team and receive a salary for their services, and teams have at least 24 and at most 99 players under contract.
- Each team has one to three managers; manager can work for at most 4 teams and receive a salary for each of their employments.
- Players cannot be managers.
- A game involves a home-team and a visiting team; additionally, the day of the game, and the score of the game are of importance; teams play with each other several times in a season(not on same day).
- Moreover, for each game played we like to know which players participated in the game and how many minutes they played.

- A General Hospital consists of a number of specialized departments (such as Maternity, Paediatric, Oncology, etc).
- Each department hosts a number of patients, who are admitted on the recommendation of doctors employed by hospital.
- There are 10 doctors, 3 nurses and 5 ward boys. Each staff has unique staff id.
- Doctors are specialists in some branch of medicine. Permanent doctors get fixed salary. Personal information like name, address, date of birth, etc. required.
- Consulting doctors visits at fixed time every day. Information like name, contact number, specialization, charges etc are required.
- On admission, the personal details of every patient like name, address, relative's name and address, patient's blood group, reason of admission, etc are recorded.
- Patients are admitted to rooms of different types, per day charges depend on room type.
- Various labs in hospital, where several tests are conducted on patient. Each test has fixed charges.
- A separate register is to be held to store the information of the tests undertaken and the results of a prescribed treatment. A number of tests may be conducted for each patient.
- Draw an extended E-R diagram for the system.