07. Enhanced Entity Relationship Modeling

[Most content has been taken from Elmasri/Navathe book]

"**Sub-classing**" relationship

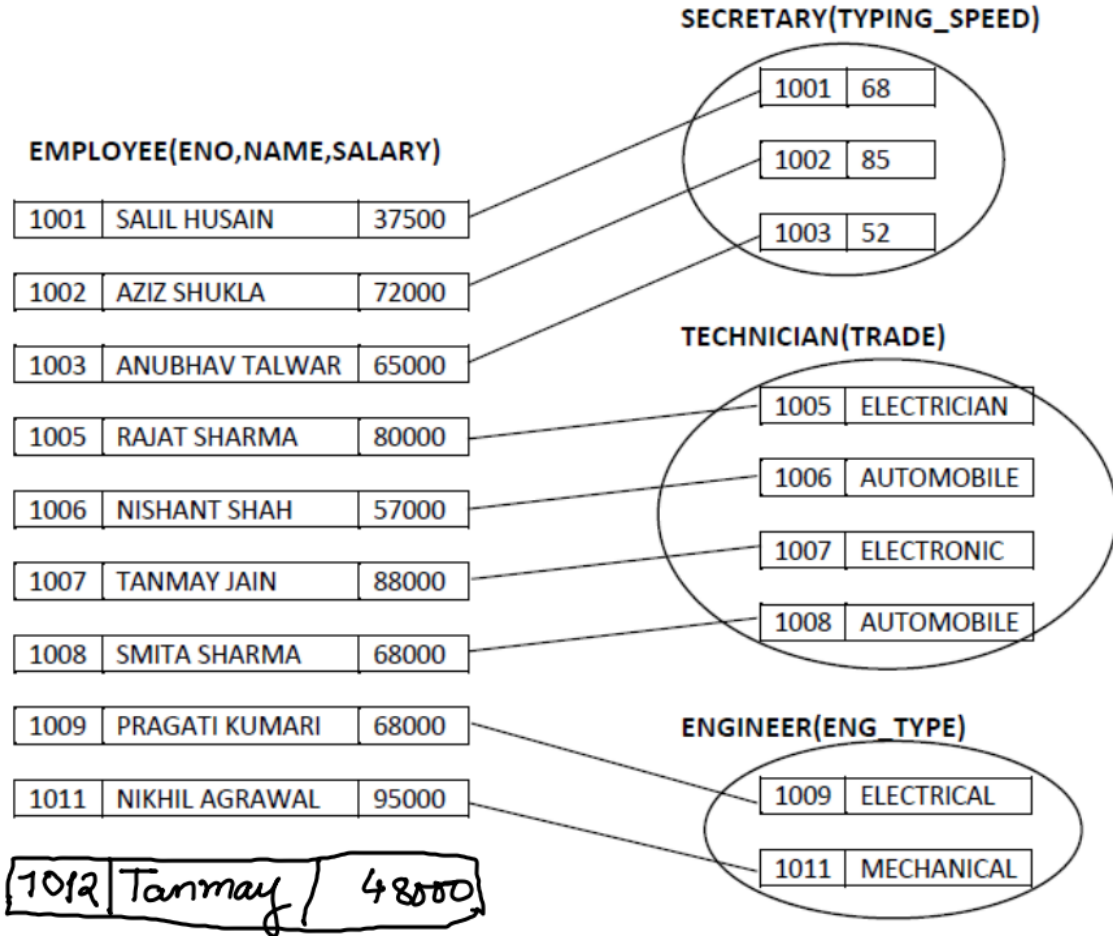
"**Sub-classing**" is a special kind of relationship between entities, and is also called a "**Generalization/Specialization**" relationship. It has concepts of

- "super-class", also called "general class"
- "sub-class", also called "specialized class"

This relationship has the following characteristics:

- "Sub-class" entities have all the attributes of its super-class entities, and may have some extra attributes, and
- "sub-class" entity set is a "sub-set" of its super-class entity set

For example, in a university database, Faculty is a special class of Employees and Faculty is a subset of all Employees in the university. Faculty would have some extra attributes like "Research Area", "publications", etc. Shown below is an example from the book Elmasri and Navathe. Here we have four entity sets: Employee, Secretary, Technician, and Engineer. **`EMPLOYEE`** is the super-class of the rest three; sets of individual sub-class are subsets of the **`EMPLOYEE`** set.



By looking at this depiction, ensure that you can validate above mentioned characteristics of "sub-class" relationships.

- A "sub-class" entity always belongs to (or related to) some super-class entity. For instance, an entity identified by "emp-no"=1001 in the "secretary" set (subclass entity set) is related to entity "emp-no"=1001 in the "employee" set (superclass entity set), and so on.
- A "sub-class" entity would have all attributes of its super-class entity type. Secretary sub-class has "typing speed" as extra attribute. The engineer sub-class entity type has an extra attribute "engineer_type", and so.
- A "sub-class" entity set is a subset of its super-class entity set.

A sub-class is best understood by "IS-A analysis".

Following statements hopefully makes some sense to your mind "Technician IS-A Employee", "Laptop IS-A Computer". Generalization/specialization is not a very uncommon relationship found in real entities. However, this kind of relationships was added later as Enhanced extension to classical ER model. ER Diagram below (taken from elmasri/navathe) depicts few examples of sub-classing relationships.

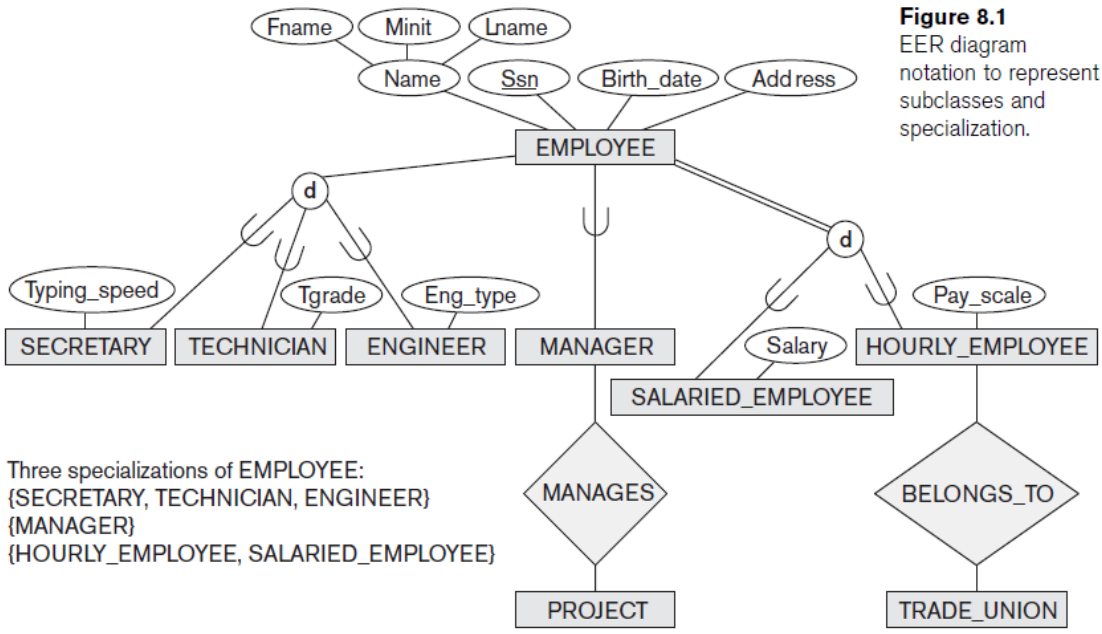


Figure 8.1
EER diagram notation to represent subclasses and specialization.

Constraints on "Sub-class" relationship:

there are of two types:

- Total or Partial Sub-classing: A sub-classing relationship is total if every super-class entity is to be associated with some sub-class entity, otherwise partial. Sub-class "job type based employee category" is partial sub-classing – not necessary every employee is one of (secretary, engineer, and technician), i.e. union of these three types is proper subset of all employees. Whereas other sub-classing "Salaried Employee AND Hourly Employee" is total; union of entities from sub-classes is equal to total employee set, i.e. every employee necessarily has to be one of them.

- Overlapped or Disjoint Sub-classing: If an entity from super-set can be related (can occur) in multiple sub-class sets, then it is overlapped sub-classing, otherwise disjoint. Both the examples: job-type based and salaries/hourly employee sub-classing are disjoint.

  Example of overlapping is not shown in diagram above; however, consider example of movie crew has sub-classes cast, director, composer, and one crew member can be belonging to more than one sub-class – overlapped sub-classing. Note the letter (d) that represents disjoint sub-classing; for overlapping (o) is placed instead. Example: page#6.

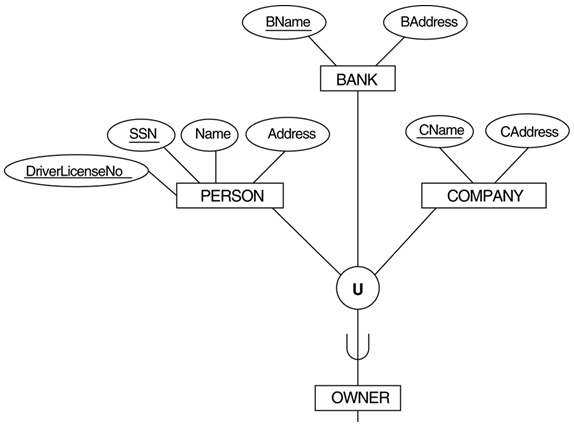
- Note that both above constraints are independent of each other: can be overlapped and total or partial or disjoint total and partial.
- Also sub-classing has transitive properties.

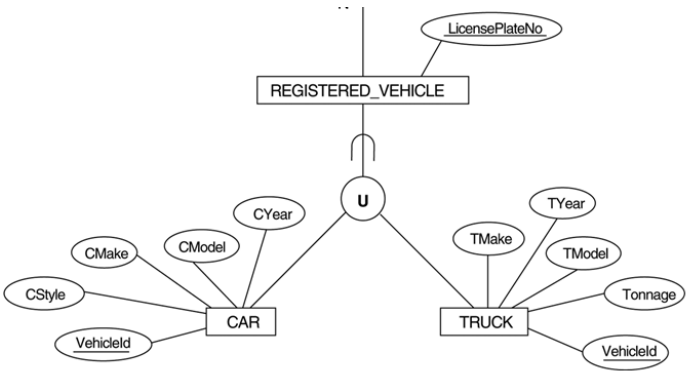
Multiple Inheritance (sub-class of multiple super classes)

- A sub-class has multiple super-classes, and as a result, such sub-class
  - Would have attributes that are the union of all its super-classes, plus it may have their "own" additional attributes
  - Its instance set is a subset of all of its "super-class" entity sets
  - For example, "Teaching-Assistant" as subclass of Employee and Student both.

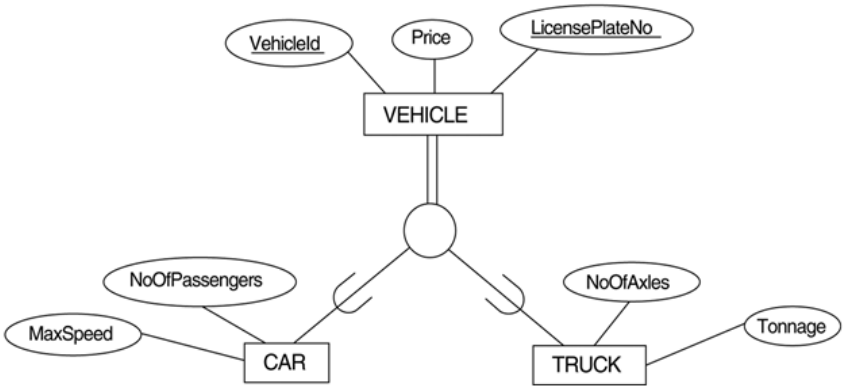
UNION

- An entity set is a UNION of sets of multiple entity types.
- Example: set of Libray Members is UNION of Faculty, Student, and Staff.
- A union relationship indicates either of type; for example: a library member is either Faculty or Staff or Student.
- Below are two examples from elmasri/navathe and shows how UNION can be depicted in ERD – Vehicle Owner is UNION of PERSON and Company, and RTO Registered Vehicle is UNION of Car and Truck.





- You might see some confusion in Sub-class and UNION; consider the example in the above figure on the right – The vehicle is a super-class of CAR and Truck; this is very much the correct example of sub-class as well but here use it differently we are saying RTO Registered vehicle is UNION of Car and Vehicle, they do not inherit any attribute of Vehicle, attributes of car and truck are altogether independent set, where is in sub-classing situation the car and the truck would be inheriting the attribute of vehicle class. Below is Vehicle as modeled as super-class of Car and Truck.



  Here are two more confusions for your mind:
  - Employee set is union of secretary, technician, and engineer (or they sub-class of employee)?
  - Student, Staff and Faculty are sub-class of Library Member?

  Bottom line is in UNION we do not inherit attributes, different sets forming union have independent set of attributes.

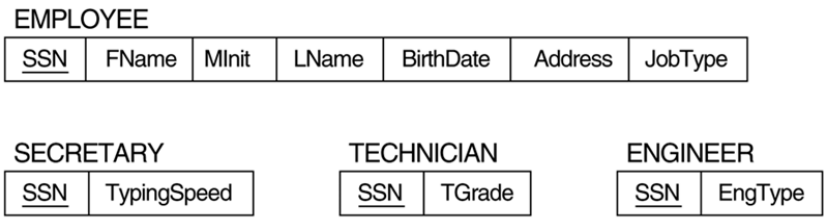
- You might also find confusion between Multiple Inheritance and UNION.
  Consider RTO Vehicle Owner in figure above.
  Do you also see Owner as "Multiply inherited class" of Person, Bank, and Company?
  It is not! Being multiply inherited mean, vehicle-owner has all the attributes of Person, Bank and Company, where as in this case a vehicle-owner entity is one of them - attributes of owner has attributes either of them. In multiple inheritance all sets of attributes are combined using AND, where as in UNION both sets of attributes are combined using OR.

EER to relational mapping rules

Generalization/Specialization

For sub-class relationships we use of one of following strategies, that are primarily derived from strategies discussed in text of elamsri/navathe.

Option1: We have relation for parent entity and for all sub-classes. Each sub-class has FK referring to parent entity relation. Example. Below is Relations derived from example …



- Option 2: We have relations only for sub-classes, and super-class attributes are repeated in all sub-class relations. Note that is only suitable when we have "total" and "disjoint" sub-classing, otherwise there is no room for entities that do not belong to any of sub-class.

CAR

VehicleId	LicensePlateNo	Price	MaxSpeed	NoOfPassengers

TRUCK

VehicleId	LicensePlateNo	Price	NoOfAxles	

- Option3: All super and subclasses are merged in one, and have class-name as an additional attribute. Example-

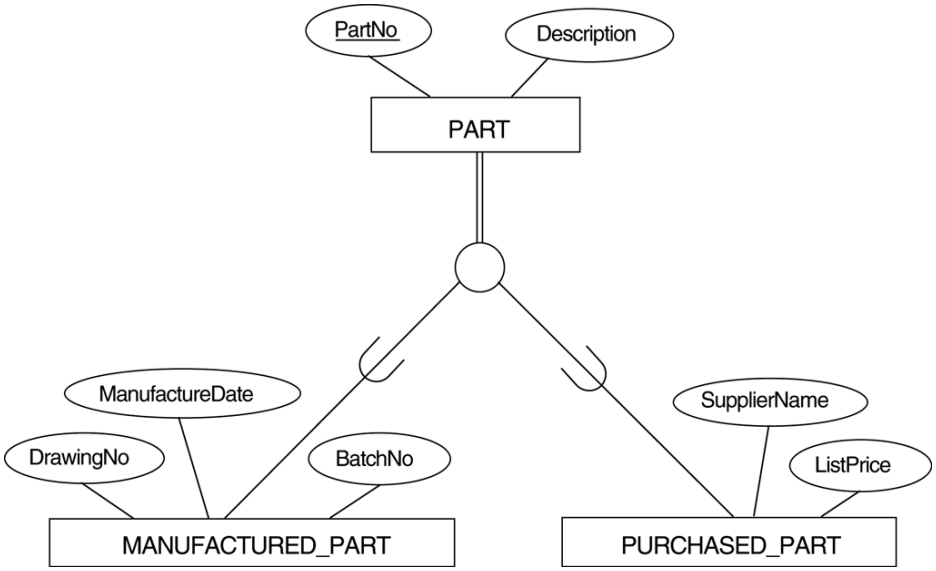
EMPLOYEE

SSN	FName	MInit	LName	BirthDate	Address	JobType	TypingSpeed	TGrade

This option is good for specializations whose subclasses are disjoint. However, this option has potential for generating a large number of null values, if many attributes appear in sub-classes (tuple can belong to only one sub-class and attributes of others will be null).

This option has benefit of avoiding JOINs.

- Option4: Again have single relation for all. This option is used to handle overlapping subclasses by including m Boolean type fields, one for each subclass.

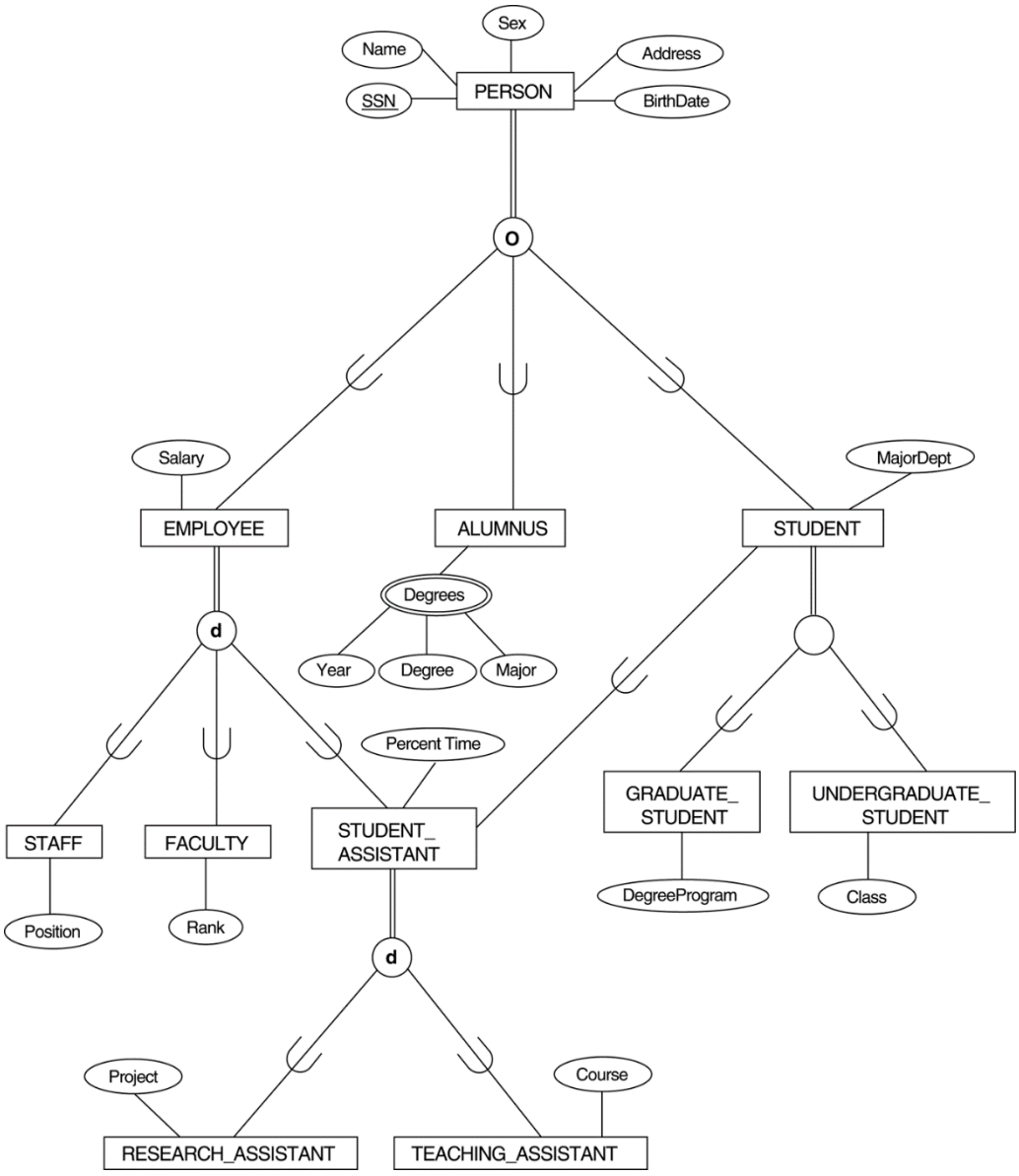


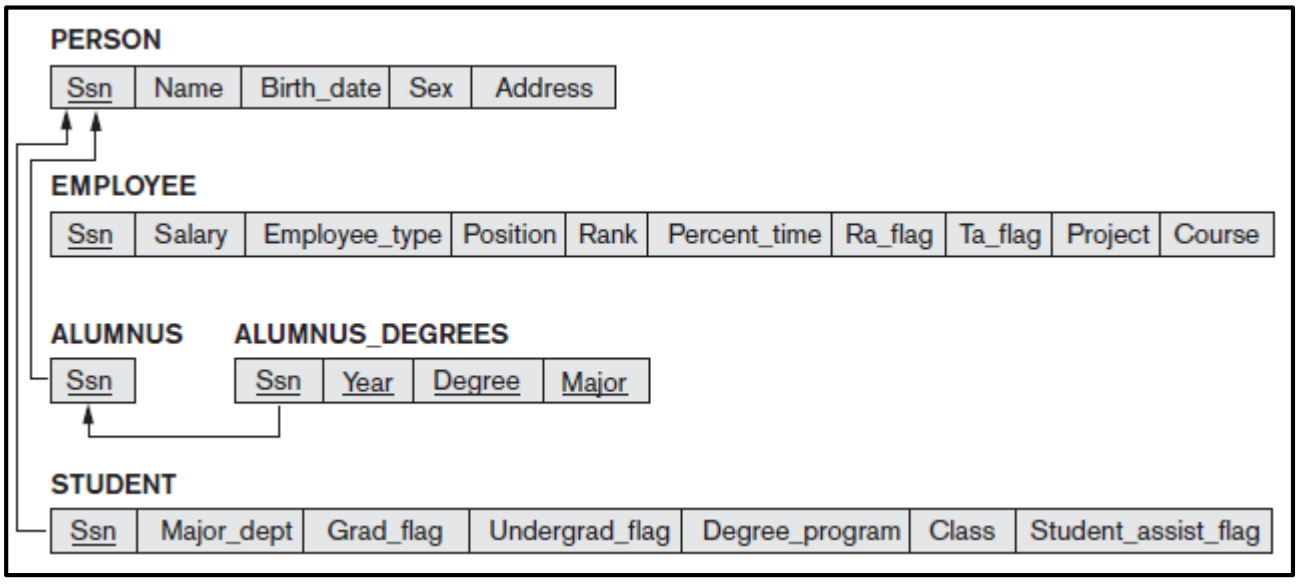
PART

PartNo	Description	MFlag	DrawingNo	ManufactureDate	BatchNo	PFlag	SupplierName	ListPrice

<---------Manufactured Part --------> <---- Purchased Part --->

- For Multiple-Inheritance. Any of the combination can be used; for employee let us say option 3, and option 4 for student and sub-classes.





- For UNION:
  - In the example of Library member, we can have a LibMemID as FK referencing to LibMember in all aggregates.
  - Another example is below for other situation-