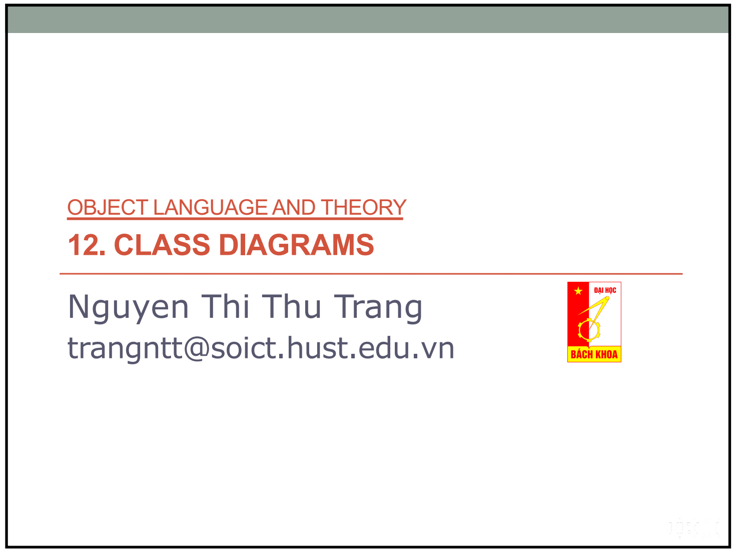

OBJECT LANGUAGE AND THEORY

12. CLASS DIAGRAMS

Nguyen Thi Thu Trang
trangntt@soict.hust.edu.vn

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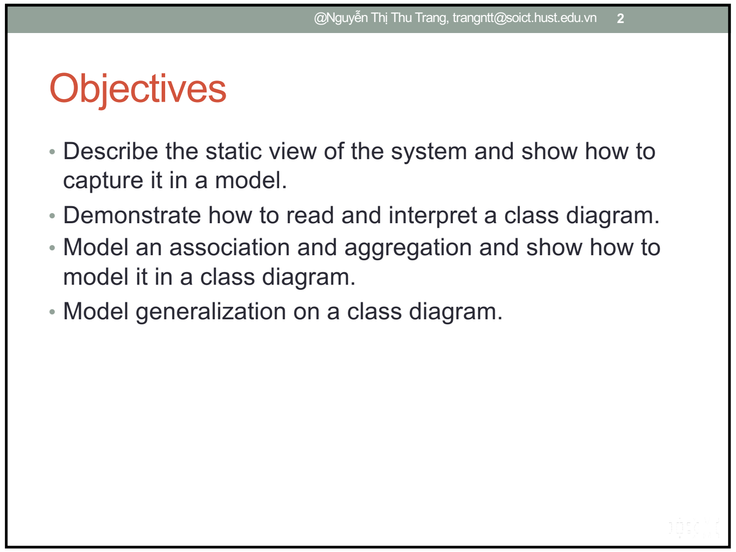

Objectives

- Describe the static view of the system and show how to capture it in a model.
- Demonstrate how to read and interpret a class diagram.
- Model an association and aggregation and show how to model it in a class diagram.
- Model generalization on a class diagram.

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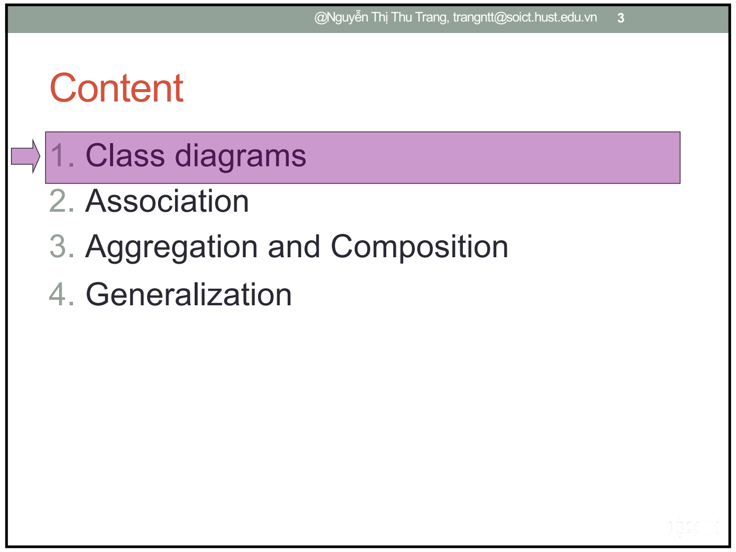

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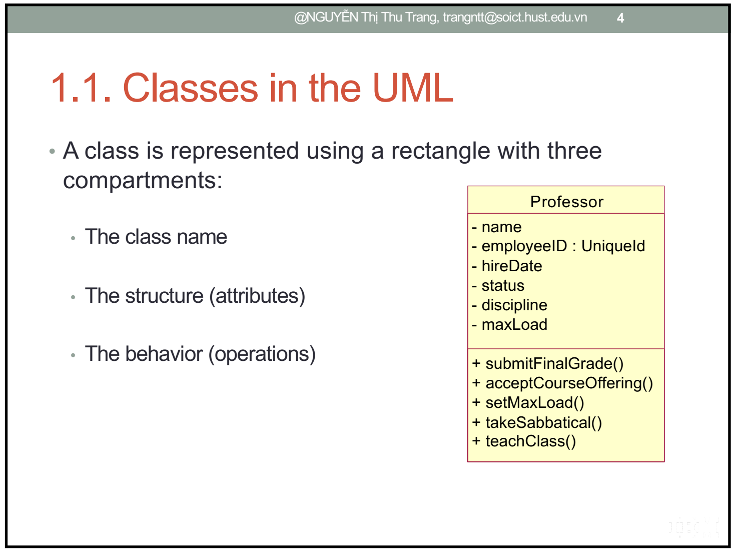
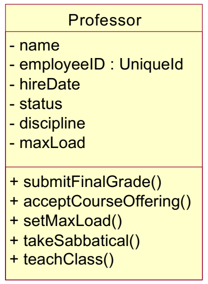


1.1. Classes in the UML

- A class is represented using a rectangle with three compartments:
  - The class name
  - The structure (attributes)
  - The behavior (operations)



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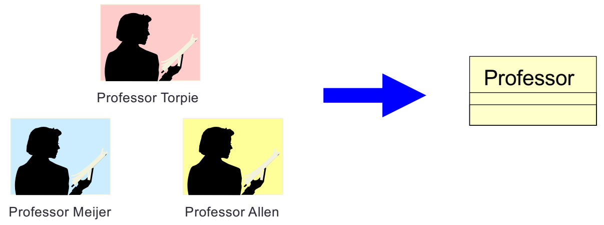
Classes and Objects

- A class is an abstract definition of an object
  - It defines the structure and behavior of each object in the class.
  - It serves as a template for creating objects.
- Classes are not collections of objects



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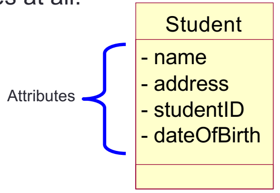
What Is an Attribute?

- An attribute is a named property of a class that describes the range of values that instances of the property may hold.
  - A class may have any number of attributes or no attributes at all.



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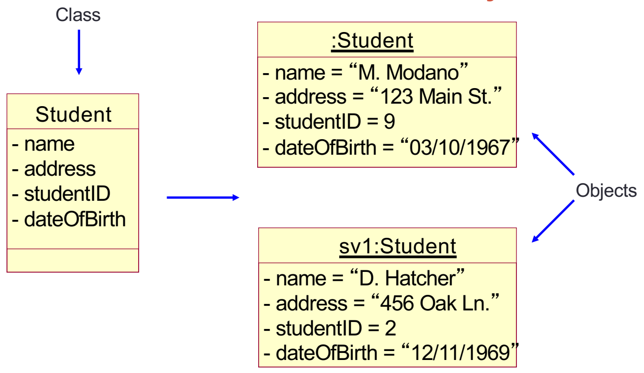
Attributes in Classes and Objects



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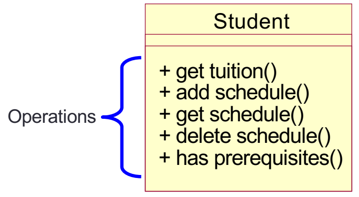
What Is an Operation?

- A service that can be requested from an object to effect behavior. An operation has a signature, which may restrict the actual parameters that are possible.
- A class may have any number of operations or none at all.



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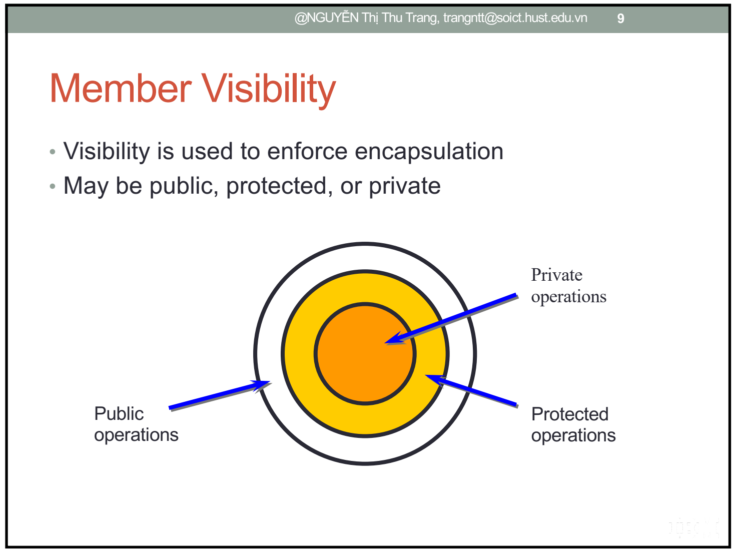
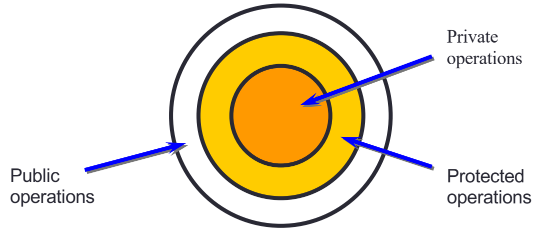


Member Visibility

- Visibility is used to enforce encapsulation
- May be public, protected, or private



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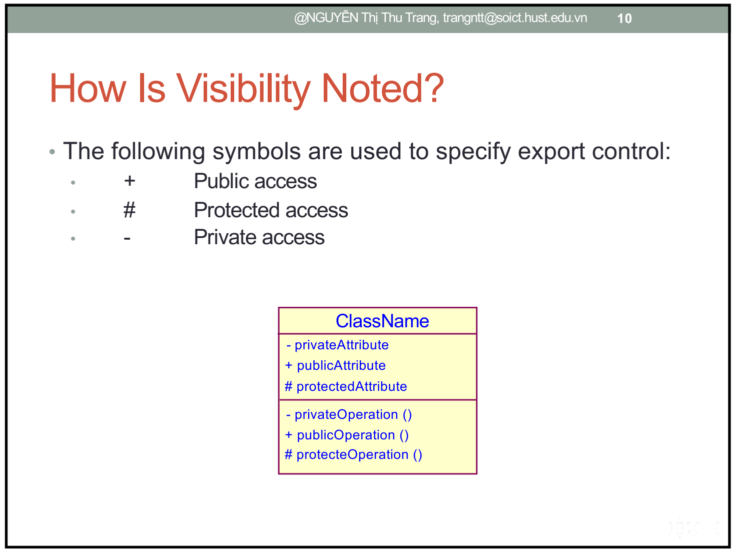

How Is Visibility Noted?

- The following symbols are used to specify export control:
  - + Public access
  - # Protected access
  - - Private access

```
ClassName
- privateAttribute
+ publicAttribute
# protectedAttribute
- privateOperation ()
+ publicOperation ()
# protecteOperation ()
```

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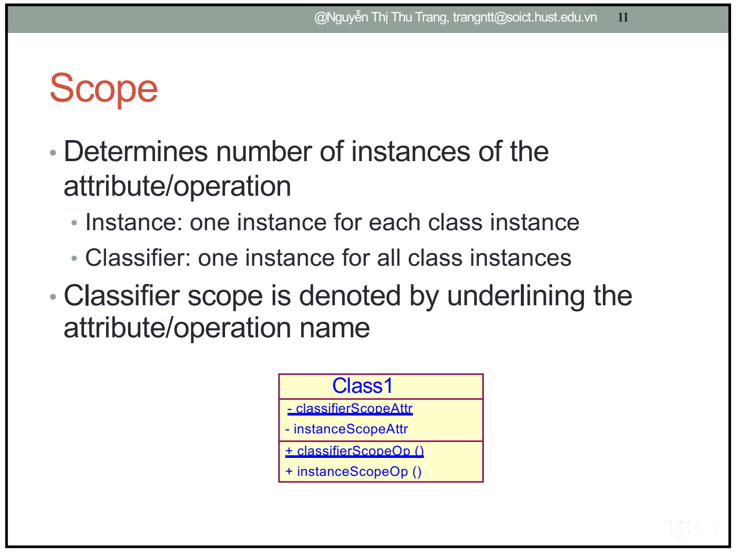

Scope

- Determines number of instances of the attribute/operation
  - Instance: one instance for each class instance
  - Classifier: one instance for all class instances
- Classifier scope is denoted by underlining the attribute/operation name

```
Class1
- classifierScopeAttr
- instanceScopeAttr
+ classifierScopeOp ()
+ instanceScopeOp ()
```

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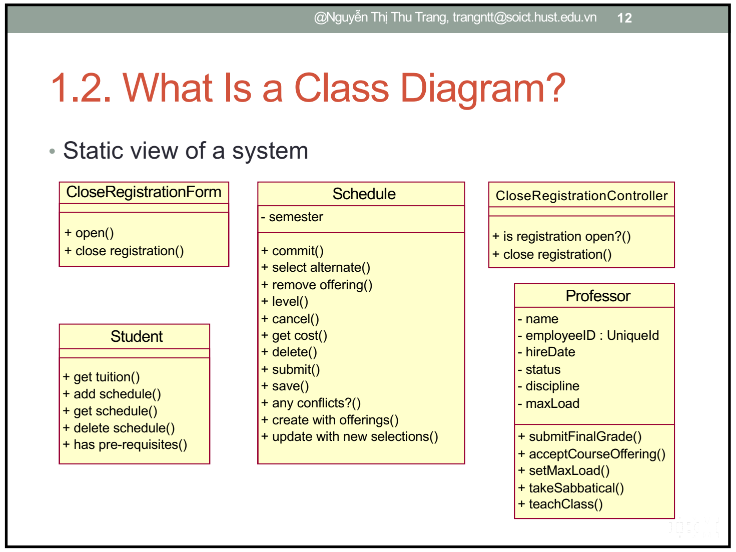

1.2. What Is a Class Diagram?

- Static view of a system

```
CloseRegistrationForm
+ open()
+ close registration()

Schedule
- semester
+ commit()
+ select alternate()
+ remove offering()
+ level()
+ cancel()
+ get cost()
+ delete()
+ submit()
+ save()
+ any conflicts?()
+ create with offerings()
+ update with new selections()

CloseRegistrationController
+ is registration open?()
+ close registration()

Student
+ get tuition()
+ add schedule()
+ get schedule()
+ delete schedule()
+ has pre-requisites()

Professor
- name
- employeeID : UniqueId
- hireDate
- status
- discipline
- maxLoad
+ submitFinalGrade()
+ acceptCourseOffering()
+ setMaxLoad()
+ takeSabbatical()
+ teachClass()
```

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Static Structure vs. Dynamic Behavior

- **Static aspects:** Software component and how they are related to one another
- **Dynamic aspects:** How the components interact with one another and/or change state internally over time.

vs

static

dynamic

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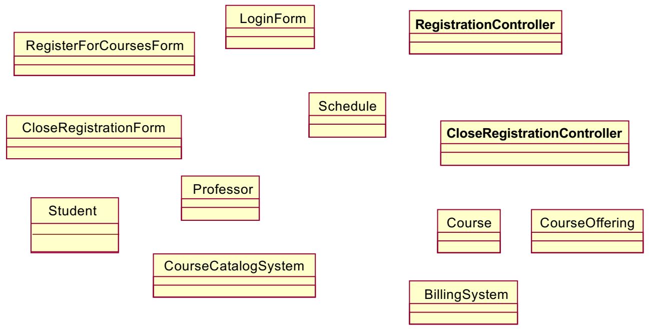
Example: Class Diagram

- Is there a better way to organize class diagrams?



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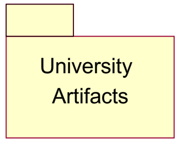
Review: What Is a Package?

- A general purpose mechanism for organizing elements into groups.
- A model element that can contain other model elements.
- A package can be used:
  - To organize the model under development
  - As a unit of configuration management



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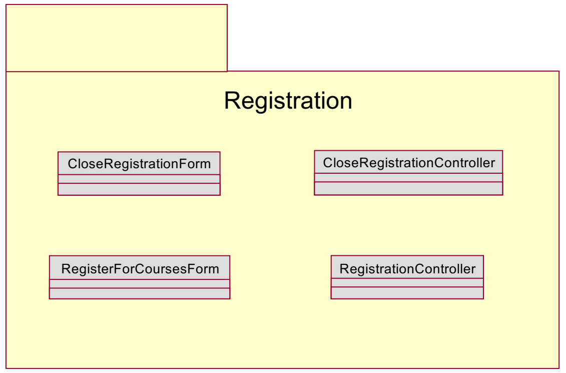
Example: Registration Package



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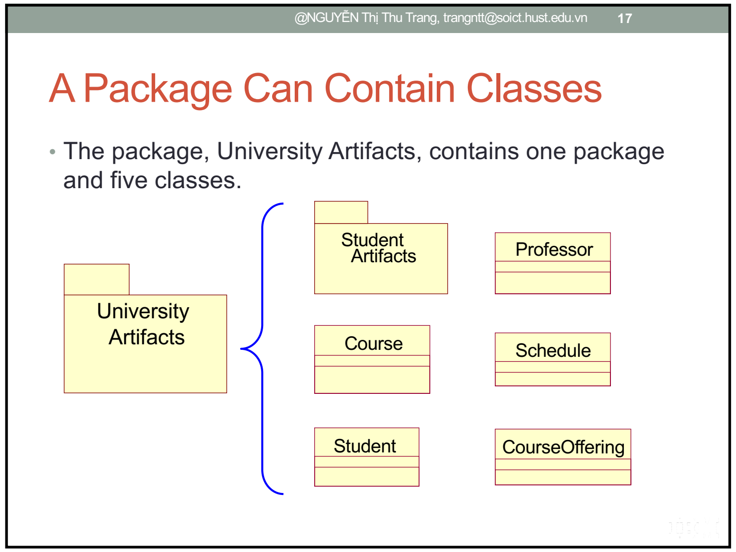

A Package Can Contain Classes

- The package, University Artifacts, contains one package and five classes.

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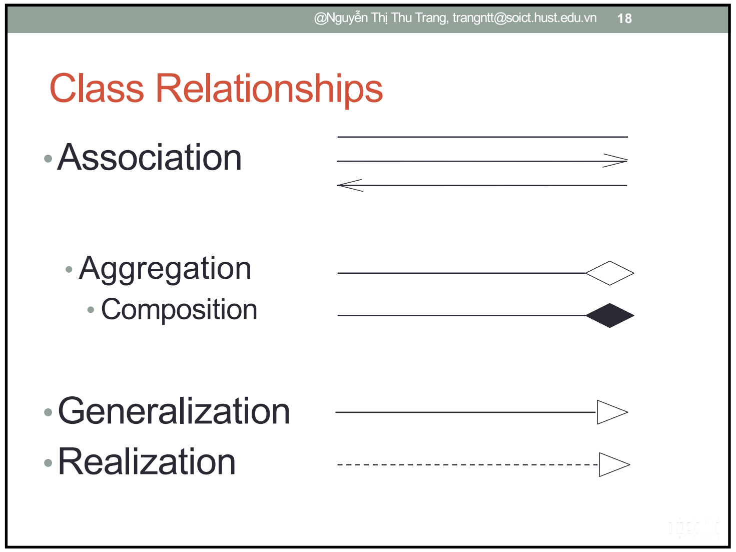

Class Relationships

- Association
  - Aggregation
    - Composition
- Generalization
- Realization

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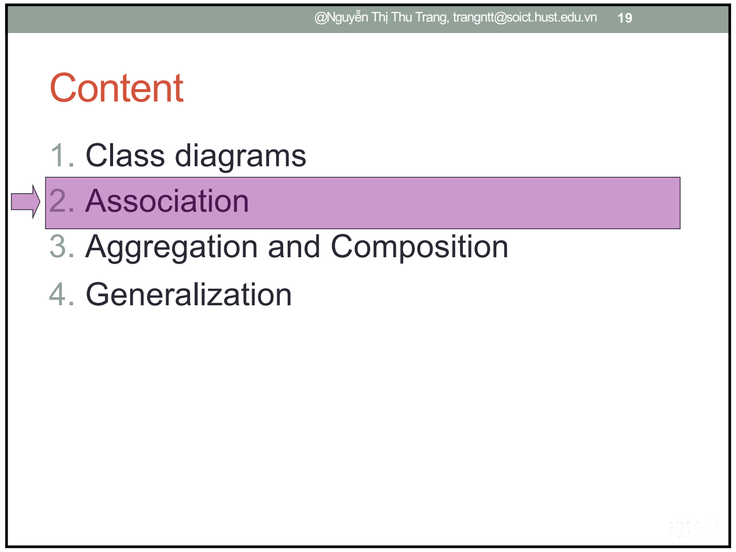

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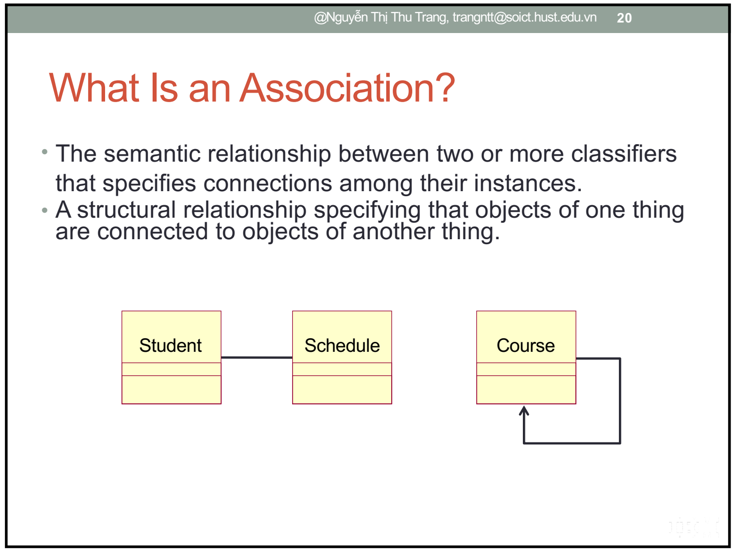

What Is an Association?

- The semantic relationship between two or more classifiers that specifies connections among their instances.
- A structural relationship specifying that objects of one thing are connected to objects of another thing.

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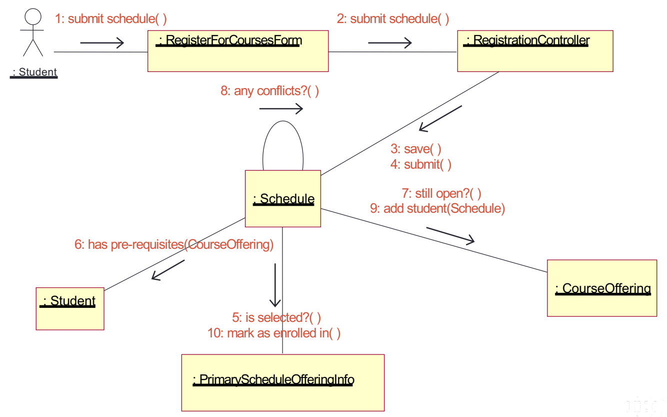
Example: What Associations?



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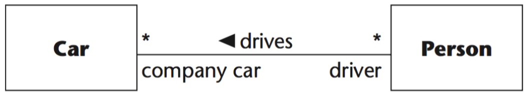
Role



- Role
  - Useful technique for specifying the context of a class and its objects
  - Optional
- Role name
  - String placed near the end of the association next to the class to which it applies
  - Indicates the role played by the class in terms of the association.
  - Part of the association and not part of the classes

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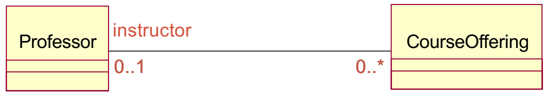
What Is Multiplicity?

- Multiplicity is the number of instances one class relates to ONE instance of another class.
- For each association, there are two multiplicity decisions to make, one for each end of the association.
  - For each instance of Professor, many Course Offerings may be taught.
  - For each instance of Course Offering, there may be either one or zero Professor as the instructor.



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Multiplicity Indicators

Unspecified	
Exactly One	1
Zero or More	0..*
Zero or More	*
One or More	1..*
Zero or One (optional value)	0..1
Specified Range	2..4
Multiple, Disjoint Ranges	2, 4..6

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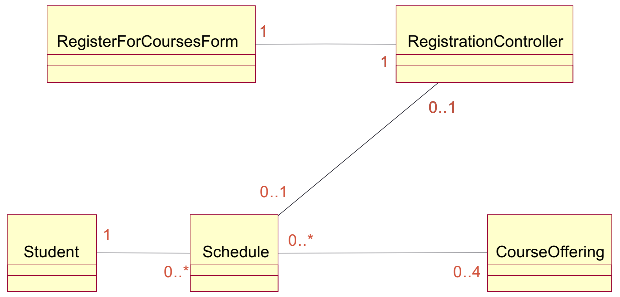
Example: Multiplicity



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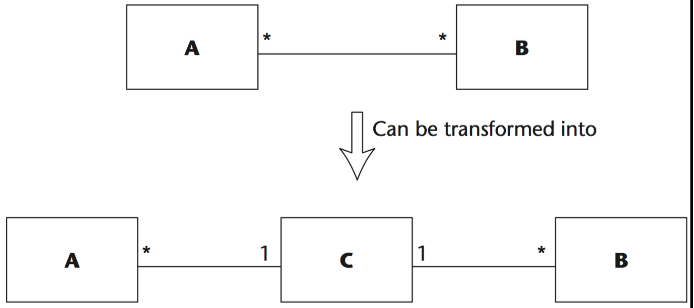
Many-to-many association



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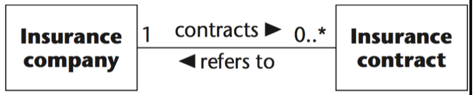
Java implementation



```java
//InsuranceCompany.java file
public class InsuranceCompany
{
   // Many multiplicity can be implemented using Collection
   private List<InsuranceContract> contracts;


   /* Methods */
}
// InsuranceContract.java file
public class InsuranceContract
{
   private InsuranceCompany refers_to;

   /* Methods */
}
```

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Content

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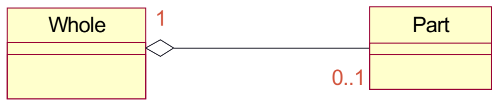
What Is an Aggregation?

- A special form of association that models a whole-part relationship between the aggregate (the whole) and its parts.
  - An aggregation is an "is a part-of" relationship.
- Multiplicity is represented like other associations.



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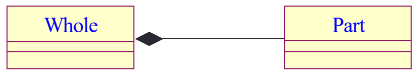
What is Composition?

- A special form of aggregation with strong ownership and coincident lifetimes of the part with the aggregate
  - Also called composition aggregate
- The whole "owns" the part and is responsible for the creation and destruction of the part.
  - The part is removed when the whole is removed.
  - The part may be removed (by the whole) before the whole is removed.



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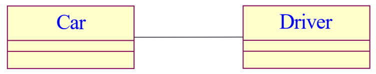
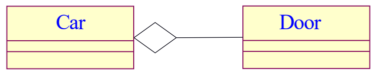
Examples: Association Types

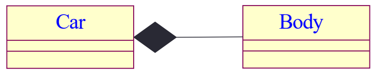
- Association
  - use-a
  - Objects of one class are associated with objects of another class



- Aggregation
  - has-a/is-a-part
  - Strong association, an instance of one class is made up of instances of another class



- Composition
  - Strong aggregation, the composed object can't be shared by other objects and dies with its composer
  - Share life-time



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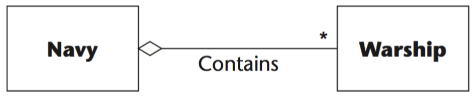
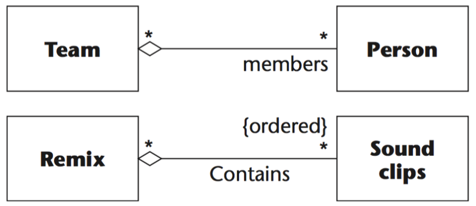
Aggregation Example



- A *shared aggregation* is one in which the parts may be parts in any wholes



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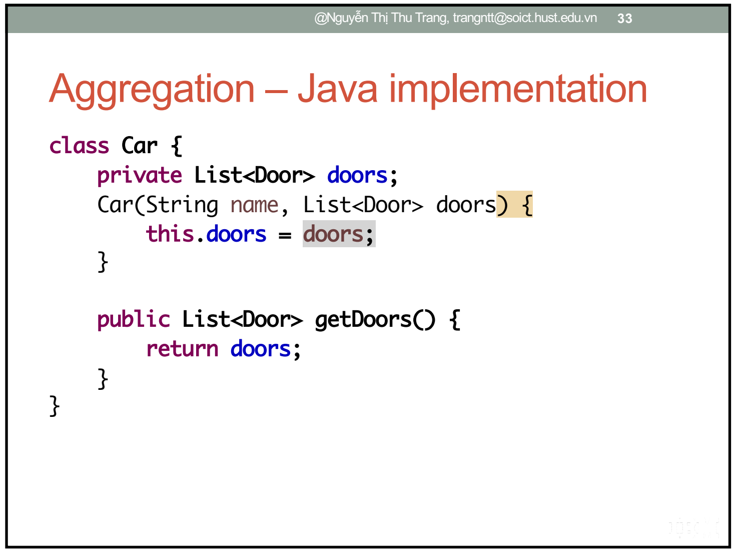

Aggregation – Java implementation

```
class Car {
    private List<Door> doors;
    Car(String name, List<Door> doors) {
        this.doors = doors;
    }

    public List<Door> getDoors() {
        return doors;
    }
}
```

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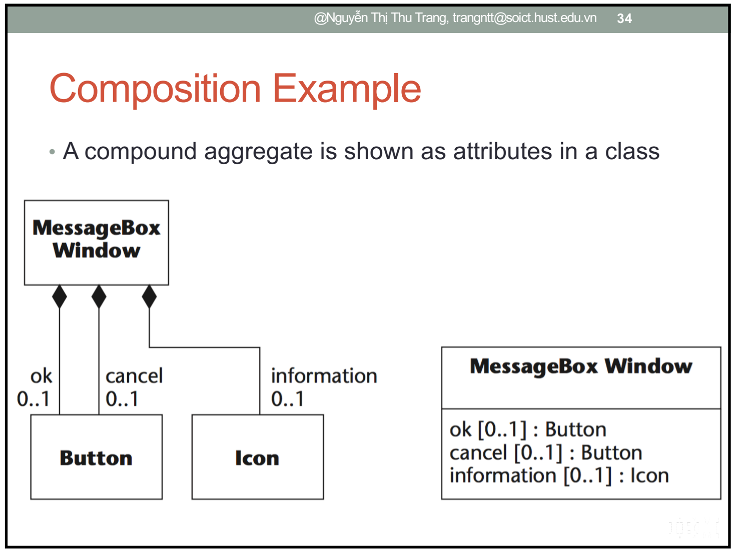
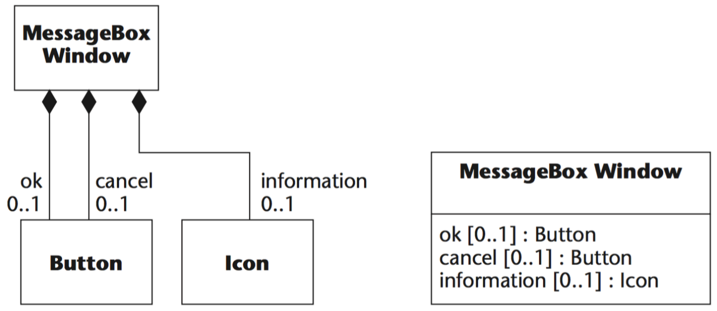


Composition Example

- A compound aggregate is shown as attributes in a class



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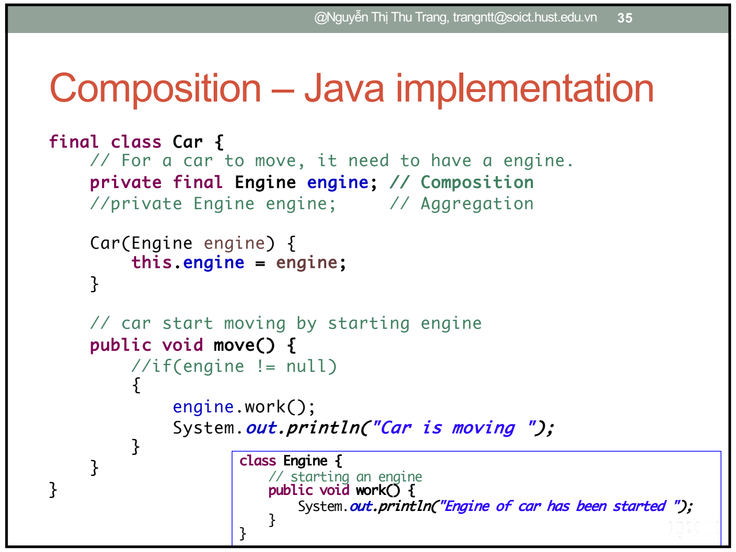

Composition – Java implementation

```
final class Car {
    // For a car to move, it need to have a engine.
    private final Engine engine; // Composition
    //private Engine engine;      // Aggregation

    Car(Engine engine) {
        this.engine = engine;
    }

    // car start moving by starting engine
    public void move() {
        //if(engine != null)
        {
            engine.work();
            System.out.println("Car is moving ");
        }
    }
}
```

```
class Engine {
    // starting an engine
    public void work() {
        System.out.println("Engine of car has been started ");
    }
}
```

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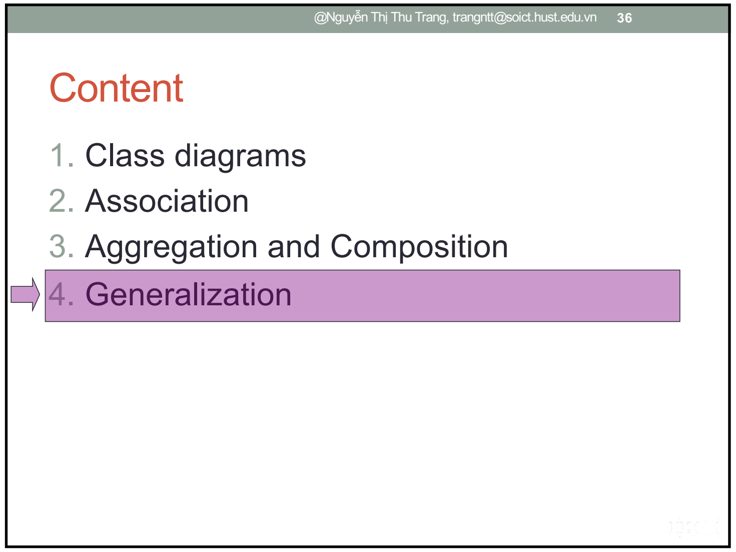

Content

1. Class diagrams
2. Association
3. Aggregation and Composition
4. Generalization

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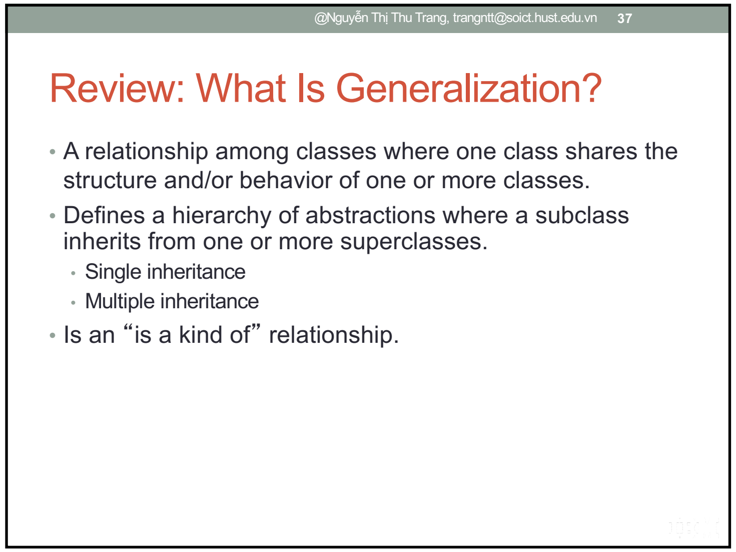

Review: What Is Generalization?

- A relationship among classes where one class shares the structure and/or behavior of one or more classes.
- Defines a hierarchy of abstractions where a subclass inherits from one or more superclasses.
  - Single inheritance
  - Multiple inheritance
- Is an "is a kind of" relationship.

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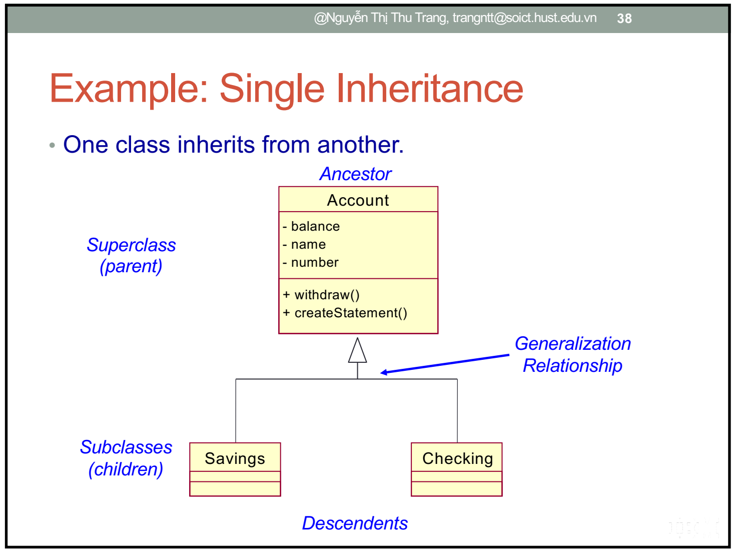
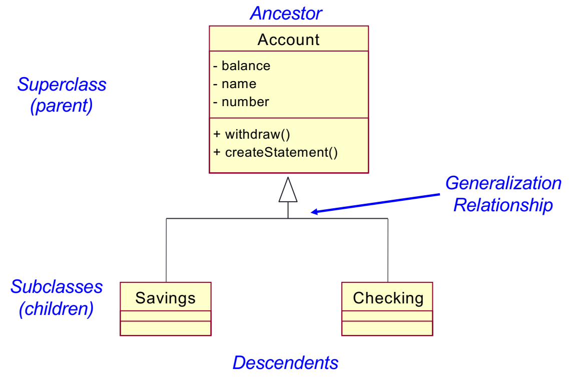


Example: Single Inheritance

- One class inherits from another.



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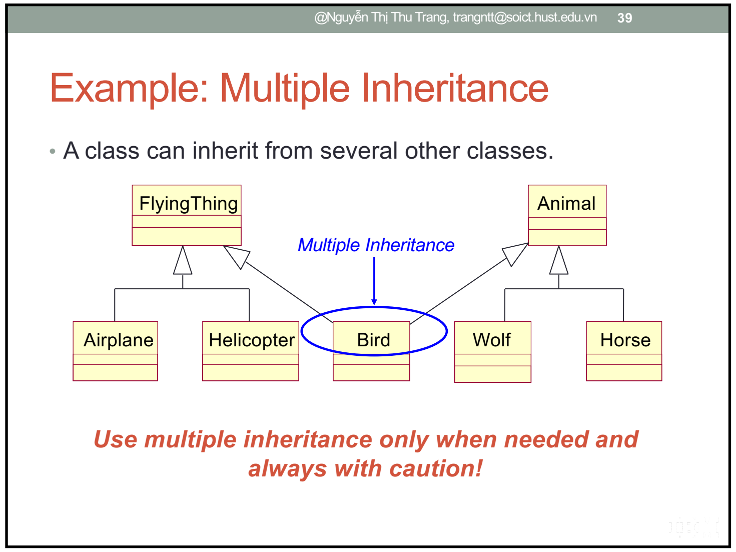
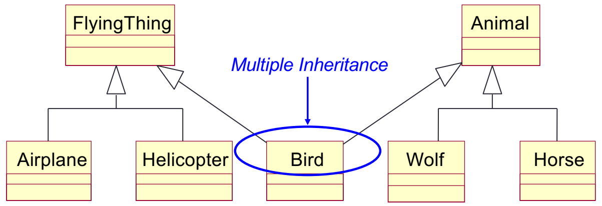


Example: Multiple Inheritance

- A class can inherit from several other classes.



Use multiple inheritance only when needed and always with caution!

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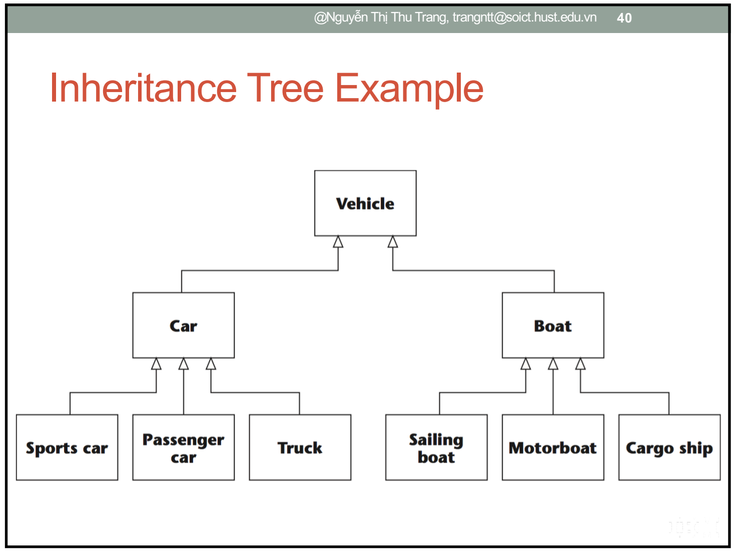
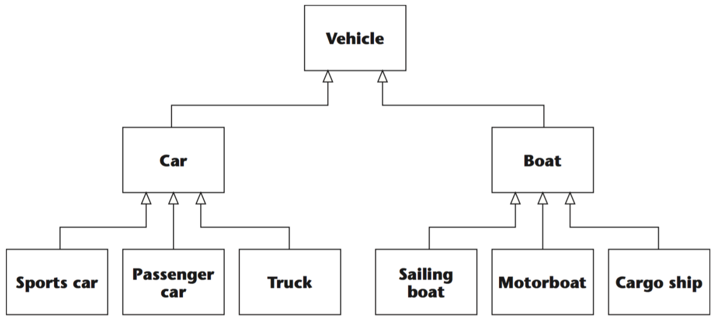


Inheritance Tree Example



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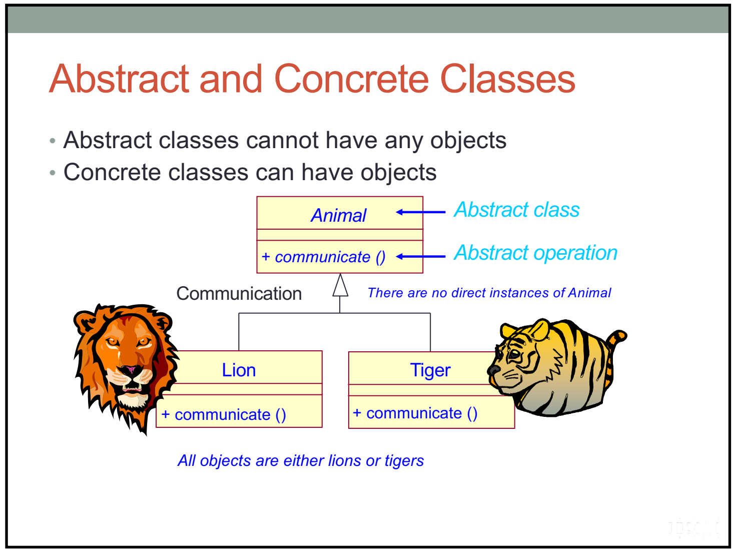

Abstract and Concrete Classes

- Abstract classes cannot have any objects
- Concrete classes can have objects

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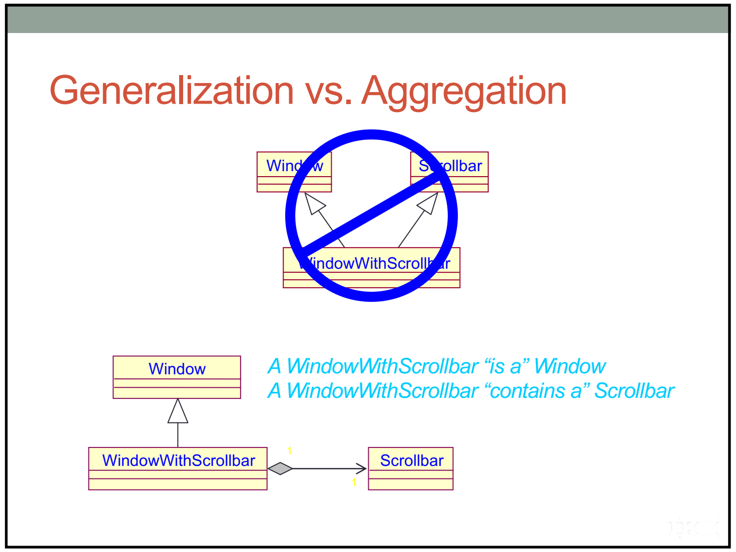

Generalization vs. Aggregation

Window
Scrollbar
WindowWithScrollbar
Window
A WindowWithScrollbar "is a" Window
A WindowWithScrollbar "contains a" Scrollbar
WindowWithScrollbar
Scrollbar

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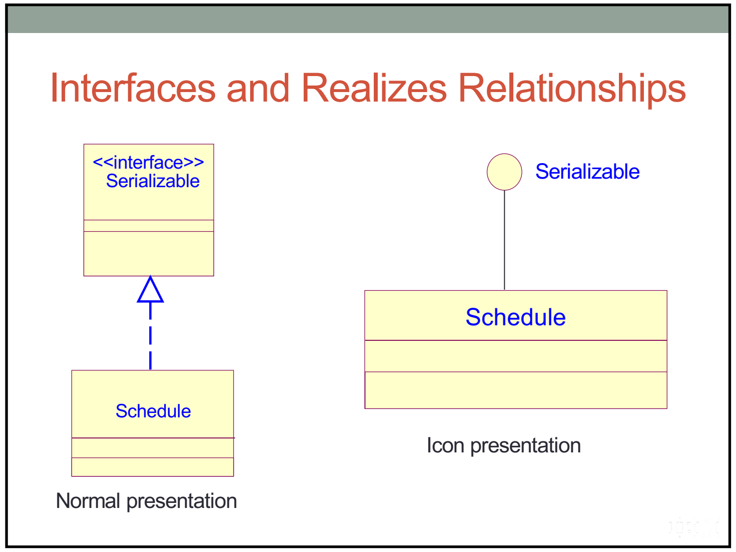

Interfaces and Realizes Relationships

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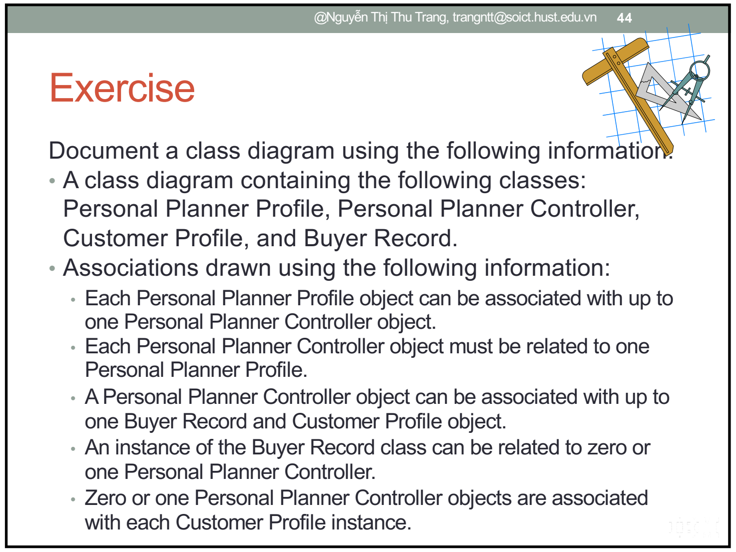

Exercise

Document a class diagram using the following information:

- A class diagram containing the following classes: Personal Planner Profile, Personal Planner Controller, Customer Profile, and Buyer Record.
- Associations drawn using the following information:
  - Each Personal Planner Profile object can be associated with up to one Personal Planner Controller object.
  - Each Personal Planner Controller object must be related to one Personal Planner Profile.
  - A Personal Planner Controller object can be associated with up to one Buyer Record and Customer Profile object.
  - An instance of the Buyer Record class can be related to zero or one Personal Planner Controller.
  - Zero or one Personal Planner Controller objects are associated with each Customer Profile instance.

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